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URBAN NATURAL AREAS: ECOLOGY AND PRESERVATION

Editors

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PREFACE

In order to preserve urban natural areas, close cooperation between environmental scientists on the one hand and field naturalists on the other is essential. To promote this goal, the idea of a handbook on urban natural areas was suggested in 1977 within the Urban Natural Systems Study Group of the Institute for Environmental Studies, University of Toronto. Five members began planning such a handbook which was designed to narrow the gap between layman and professional, and which was to be of interest and value to both parties. A further step was taken when the Study Group, in conjunction with the Federation of Ontario Naturalists, held a workshop on the subject of "Citizen Participation in Conserving Natural Areas" which explored ways in which lay people could cooperate with professionals in the task of preserving specific areas. That workshop reaffirmed the need for a handbook.

During the winter of 1977-1978 fourteen persons from the University of Toronto together with an environmental lawyer and two field naturalists cooperated in writing a first draft. After editing by Professor W.A. Andrews, review copies were sent to eighteen people across Canada active in environmental problems and the preservation of urban natural areas (see list of acknowledgements). The comments received contributed significantly to the text as finally printed. However, the Editors take responsibility for any errors or omissions that might remain.

Readers are invited to suggest corrections or elaborations that could be incorporated into a Second Edition of this Handbook.

W.A. Andrews and J.L. Cranmer-Byng

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This book is very much a cooperative work. Not only was it written by a team of authors, but the first draft was reviewed by a number of experienced naturalists. We gratefully acknowledge the comments and constructive criticisms we received from the following:

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Dr. Joyce Reddoch, Ottawa Field Naturalists Club

Mr. Ronald Reid, Staff Environmentalist, Federation of Ontario Naturalists

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We also acknowledge the help of Professor J.B.R. Whitney, Department of Geography, University of Toronto and Mr. J. Swaigen, formerly of the Canadian Environmental Law Association.

A special word of gratitude is due to Mrs. Lois Andrews who typed the draft and the revised versions of the book.

Finally, we thank the referee for his helpful review of the second draft, and for writing the general introduction to Chapter eight.

The Editors

Cover photo: Jean MacDonald

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CHAPTER 1

INTRODUCTION TO THE STUDY OF URBAN NATURAL AREAS

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University of Toronto

1.1 SOME DEFINITIONS

Before discussing the purpose of this handbook and how to use it, we need definitions for three frequently used terms: *ecosystem*, *natural system* and *greenspace*.

ECOSYSTEM

An ecosystem, or ecological system, is an integrated complex of living (biotic) and nonliving (abiotic) components, in which each component is influenced by the others. Thus a pond is an ecosystem, as is a lake, a river valley, a woodlot, a cornfield, a city park, and a city housing development.

We encourage you to plan your field studies at the ecosystem level. In other words, do not conduct a study of just the birds, the trees, or the soil. Instead, conduct an integrated study of the ecosystem in which you are interested. Data that show the interdependence of biotic and abiotic factors are much more useful than are plant lists, bird lists, and other isolated information.

Figure 1-1 can serve as a model around which you can design your field studies.

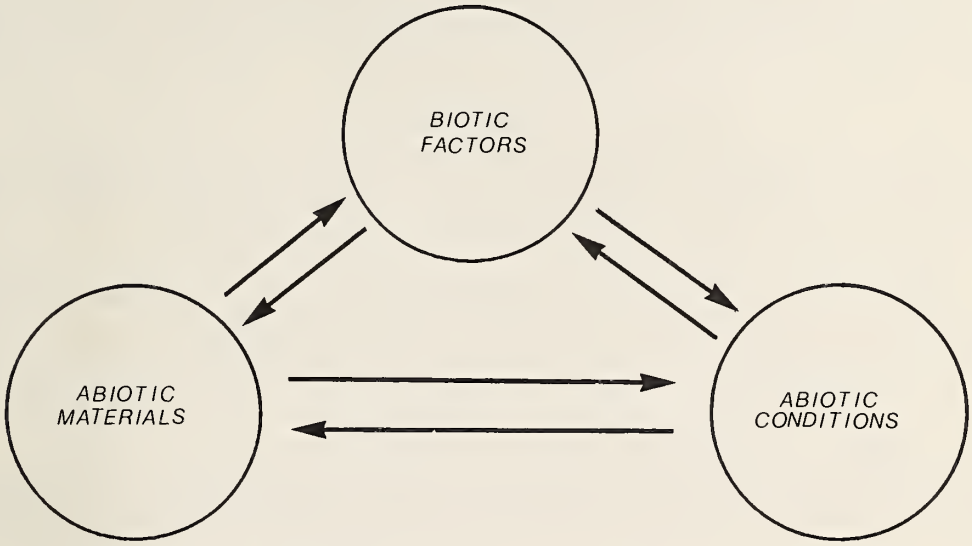

Fig. 1-1. The ecosystem concept

Biotic factors include all living things. *Abiotic materials* include macro-nutrients (N, P, K), micronutrients, detritus, pesticides and other non-living substances. *Abiotic conditions* include soil and climatic variables, temperature, light intensity, wind speed and direction, relative humidity, and other physical factors in the environment of the ecosystem. The arrows show the interdependence of all these components. You should try to do likewise in your field studies.

NATURAL SYSTEMS

Ecosystems can be conveniently divided into two categories: natural systems and human-made systems. Ponds, lakes, marshes, river valleys, and woodlots that have not been "manicured" by humans are among the numerous natural systems in this country. Many city parks and all urban housing developments are among the human-made systems. A large and old cemetery can have aspects of both natural and man-made systems. The "urban natural areas" referred to in the title of this book are natural systems. Thus, *a natural system is defined as an ecosystem that has not been manipulated to any great extent by humans, or has recovered from earlier manipulation.*

GREENSPACE

The focus of this book is on natural systems as a working whole such as a marsh, an island, a shoreline of a lake, a river valley with its watershed, or a ravine and its stream. In an urban environment, however, it is not always possible to study complete natural systems because they tend to be broken up by blocks of buildings, roads, bridges and other man-made obstructions. Therefore, we need a very general term for areas which only form a small part of a natural system, or are so surrounded by buildings and roads as to be isolated areas of green in a cityspace of concrete and asphalt. For this purpose we use the term "greenspace". Thus, *greenspace is defined as any area in an urban setting which contains a sufficient diversity of plant life, including trees, shrubs and herbs, to afford a clear contrast to the built environment in the city.*

Humans living in cities need greenspace to provide visual relief from the glare (or drabness) of much of their daily surroundings: the refreshing and restful green colours of spring and summer, the golden richness of the autumn colours. Greenspace also brings a feeling of visual relief because of the variety of its natural forms and shapes, the rounded surfaces, the curves, the intricately interlocking patterns of branches and leaves, and the special quality of "livingness" and change which wild plants growing in natural profusion exhibit but which constructions designed by humans in non-living materials never attain. Along with this sense of visual relief the city dweller may also experience relief from loud noise and from the stress of constant movement, and, instead, may enjoy the slower pace of the natural order. Thus, greenspace can provide people in cities with the chance of a brief respite of quietness, a sensation of restfulness in an otherwise distracting way of life. An entire city without greenspace would be unbearably abrasive on its inhabitants, harsh to the eyes, and hard on the ears and the mind.

Where trees, shrubs and herbs flourish, wildlife will also live. By wildlife we mean birds, mammals, insects, reptiles, fish and all of the other wild animals which move about freely and carry out their life cycle independent of human management. This they can do in an urban environment provided that there is greenspace of sufficient habitat diversity to provide them with the food and shelter they need. Not all greenspace is capable of supporting much wildlife. But greenspace which *is* capable of sustaining a variety of wildlife can usefully be designated "natural areas". Our definition of natural areas in a city is subjective and unscientific, since to the purist no area in an urban environment can, by definition, be natural. However, as a working definition for the purposes of this handbook, we define *an urban natural area as an area in which vegetation of all kinds has been allowed to grow in its natural state without human management, where wildlife is able to exist independent of human assistance, and where human impact is at a minimum.* In such areas people can rest a while, observing the wildlife around them - the busy activity of squirrels, birds, butterflies, and other forms of life. Here people can feel the intricate natural, as opposed to the man-made, environment around them. In a natural area everything is self-regulating. A natural area is not dependent on human skill to maintain its life-sustaining balance. Greenspace, natural areas, and wildlife are vital to the well-being of city dwellers: they provide the perfect contrast and complement to our human-centred city culture.

1.2 FOR WHOM THIS HANDBOOK IS WRITTEN

This book is intended as a guide for all who wish to understand urban natural systems and areas, and to be alert to the continual modifications that such systems are undergoing as the result of the process of urbanization and the pressure of people. It contains not only descriptive material but also material on the dynamics of change and the unstable nature of most greenspace within cities. As a follow-up, there is practical information on how to set about trying to preserve (or "conserve", if you prefer) the natural areas and systems within your own city. This should be of interest to a very wide segment of the population. Perhaps we can define a little more clearly for whom the book is intended by stating for whom it was not written. It is not intended to be an exhaustive textbook for the use of specialists in the field of urban ecology. Instead, it has been compiled primarily for the use of university students, secondary school classes, field naturalists, groups of concerned citizens, and residents' associations, the members of which may have some expertise in identifying plants or birds, or experience in the political process, but who need a wider range of ecological information, and, above all, guidance in methods for undertaking a sound field study and for presenting their findings in an effective way. We also hope that the handbook will be used to advantage by journalists, as well as radio and television script writers and producers, all of whom bear some responsibility for shaping public opinion. The handbook can provide them with an access to sound principles, methods, and information.

Finally, we hope that the handbook will be used regularly by elected representatives, the people who make the decisions which affect the quality of the natural environment in our cities. Their decisions may have adverse effects on the quality of natural areas, not only during their own terms of office, but much later, sometimes long after the politicians who voted on these issues are out of office, or dead. Sometimes their decisions may have beneficial results for which citizens in the future will thank them. This handbook should give politicians the opportunity to understand the environmental implications of the issues on which they are voting. It should be of value especially to local politicians - borough councillors and ward aldermen - in decision-making, for it is at municipal and borough level that so many of the decisions are taken with respect to urban natural systems and areas.

1.3 ORGANIZATION OF THE HANDBOOK

Chapter 2 focusses on the interplay between humans and the environment in an urban setting. Chapter 3 suggests criteria and methods for the identification of environmentally significant areas. Then Chapters 4 and 5 provide strategies, both political and legal, for action on environmental issues relating to environmentally significant areas and other urban greenspace. Chapter 6 discusses the growing importance of the environmental impact assessment process in relation to urban natural areas; it is included to help you evaluate an impact assessment. If you are appearing before a hearing which includes an environmental assessment, you will then be in a position to spot the important points which the other side has omitted in its assessment.

Chapters 7, 8 and 9 will help you understand the geophysical, biological and socio-economic characteristics of the urban natural area being threatened. If it is necessary to collect field data, these chapters will provide you with some useful guidelines.

Finally, Chapter 10 describes how to write up the results of a field study into a report that can be submitted at a hearing or public meeting.

If you follow the strategies outlined in this handbook, you should be able to become effectively involved in conserving, within an urban setting, those natural areas that are likely to suffer environmental damage and deterioration. Further, you will then be ready to become involved at the political and legal level, armed with facts collected in a proper scientific fashion and presented rationally.

The basic method used throughout the handbook is the "systems approach". We stress the importance of thinking in ecological wholes. We also believe that there are some valid differences between the problems encountered in the study of natural systems in an urbanizing area and the problems in a rural area. To understand these special urban problems, we must understand the complex interrelation of human impact on these urban natural systems. We must know something of the aims and problems of the urban planner, the developer, government employees in various ministries and departments, and the complicated interaction between the civil servants and the politicians at the urban levels. As well as being based on the ideas of systems analysis, the handbook also uses the do-it-yourself approach. It is concise and practical rather than exhaustive and theoretical in its treatment of what is, essentially, a practical problem - "the preservation of urban natural areas".

In conclusion, we hope that this handbook will make practical "know-how" available in a convenient form to anyone who wants it. We believe that it will serve to make those who use it more environmentally aware, and, will lead them to use ecological concepts and terms with more precision. We have purposely made it comprehensive in scope and broad in principles and methodology so that it can be applied to most urban areas in North America - with, of course, modifications to meet local conditions.

CHAPTER 2

URBAN OPEN SPACES

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2.1 INTRODUCTION

In a context of competing land use pressure and limited financial resources, this chapter explores ways in which urban outdoor environments can best be created, protected and intelligently used. Open space is, therefore, considered in its broadest definition. Parkway belts, utility corridors, reclaimed extraction sites and the rural landscapes adjacent to population centres are included. Identification of both available land resources and patterns of use are essential aids to developing successful responses. This necessitates imaginative planning and skillful design, in addition to public commitment.

2.2 AN HISTORICAL OVERVIEW

An understanding of the historic evolution of urban public natural lands in Canada and of changing attitudes toward these resources is required if new policies governing their use and protection are to emerge. What follows is a brief overview of the historical panorama which often is the background to current issues. During colonization, the struggle of European settlers adjusting to the rigours of an often harsh climate in a wilderness setting kept the population of new communities relatively low, thus slowing the initial rate of impact on natural areas, and limiting impact to specific sites. In most 18th Century settlements, there was relatively little land specifically set aside for outdoor recreational use. Public outdoor spaces were either cemeteries or churchyards. The town commons where stock grazing, children's play, and military drill simultaneously competed for accommodation, was frequently bleak, muddy and uncared for. Little thought was given to drainage, siting, seasonal activities or to natural attributes, in the few public open spaces which existed; they were often the result of accidents of history. In part, this 18th Century attitude toward open space can be attributed to a perception of the seemingly limitless wildlands which surrounded settlements, to a realistic need to place survival before aesthetics, and to a land ethic which stressed human dominance over nature and the exploitation of resources.

As populations in these settlements increased during the following century, and as towns became cities, there emerged some conscious attempt to establish and preserve open space. During the early 1800's, enclosed gardens and private estates were used to test horticultural techniques developed in both Britain and France (for example, Prince's Lodge in Nova Scotia, and Kingsmere in Quebec). Some of these were to be adapted later to the planning of public park land.

The notion of rugged "picturesque" gardens as places for people to enjoy and to observe nature slowly spread from England to Canada. English and French Canadian horticulturists strove to adapt European design and planting techniques to a harsher climate, and to utilize native vegetation more creatively.

The early British public parks of Birkenhead in Liverpool (1843) and Regent's Park in London (1841), exemplify major breakthroughs in urban open space dedication. These precedents influenced park planners in both Canada and the United States. The Halifax Gardens (1860) reflects this less formal thinking about public space, while Mount Royal Park in Montreal (1876) designed by Frederick Law Olmstead, a renowned American landscape architect who designed several projects in Canada, illustrates a more sophisticated approach to the introduction and enhancement of natural areas within major population centres (Fig. 2-1). Laced with scenic drives and pathways, tree and shrub massings are used to define and shelter recreation areas, and to create wildlife habitats.

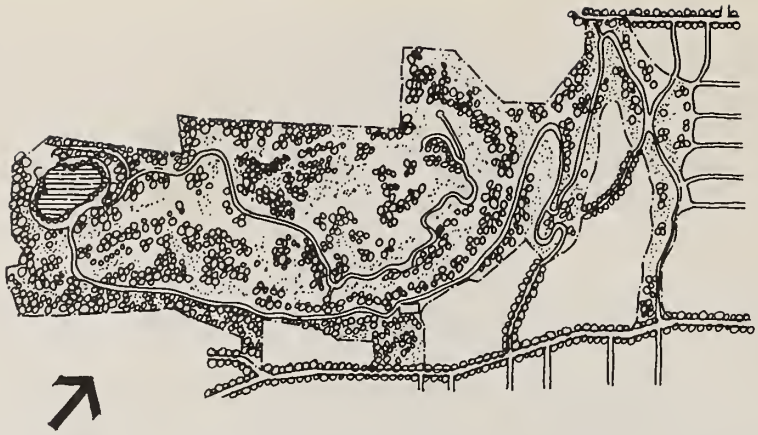


Fig. 2-1. F.L. Olmstead's Mount Royal Park, Montreal, Quebec

Under the auspices of the Niagara Parkway Commission in 1879, Olmstead also prepared a master plan for the scenic lands surrounding Niagara Falls. Although there was little coordination between the United States and Canada, an overall plan was eventually implemented. This resulted in the establishment of a landscape of regional ecological significance, and the legal authority for protection of the Falls.

During this early period of urbanization, the main advantages of cities were those of lowered transportation and communication costs. However, within urban areas, shorter travel distances also meant higher densities and increased congestion. To counteract such high densities in early industrial cities, various plans gradually emerged to maintain and create natural environments within or near cities. During the last part of the 19th Century, F.L. Olmstead, and Ebenezer Howard, an English town planner, both advocated notions such as the garden city. Trees and natural open spaces were often thought of by these planners as the vital "lungs" of the city, necessary to assure human health. As immigration proceeded westward, occupants of new prairie and Pacific Coast cities also recognized the need to incorporate outdoor areas for human enjoyment and to assume the continuation of essential natural processes.

Vancouver's Stanley Park (Fig. 2-2) and Regina's Wascana Centre Parkway (Fig. 2-3) exemplify major urban greenspace in Canada's western cities. Portions of both parks were designed by the noted Canadian landscape architect Thomas Mawson. Victoria's Butchart Gardens (1904), launched by a wealthy family with an avid interest in plants, is now a public amenity, and an early example of quarry restoration. During the Victorian Period in Canada, street planting and the development of residential gardens were encouraged, although many landscapes with a potential for general public enjoyment were still in private ownership.

An added enhancement of the city dweller's awareness of and access to natural landscapes was the creation of the first two Canadian National Parks (Banff and Jasper) and the establishment of a Dominion Parks Branch in Ottawa during the early 1900's. Although these parks were in wildland settings far removed from large population centres, their existence also encouraged awareness of natural areas in and around urban centres, since most National Park visitors were city dwellers. The early National Parks were also popular with wealthy Europeans seeking a wilderness experience in North America.

As the populations of cities increased, the growth of railroads and the subsequent development of the private automobile profoundly affected distribution and use of open space around Canadian cities during the late 19th and early 20th Centuries. Industry and rail yards spread along waterfronts. Wetlands were often filled to accommodate these uses. New communities clustered along transit routes.

The paving of roads and the spread of economical street lighting made it easier to live outside the city core. The streetcar made surburban sprawl, along linear transit routes, possible. Soon, however, open land between commuter lines

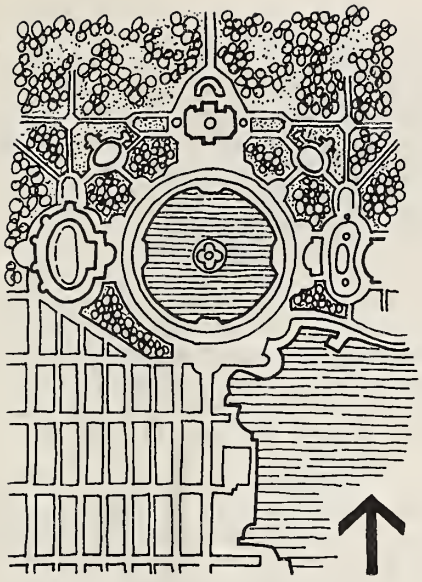


Fig. 2-2. T. Mawson's scheme for Coal Harbour, Vancouver, B.C.

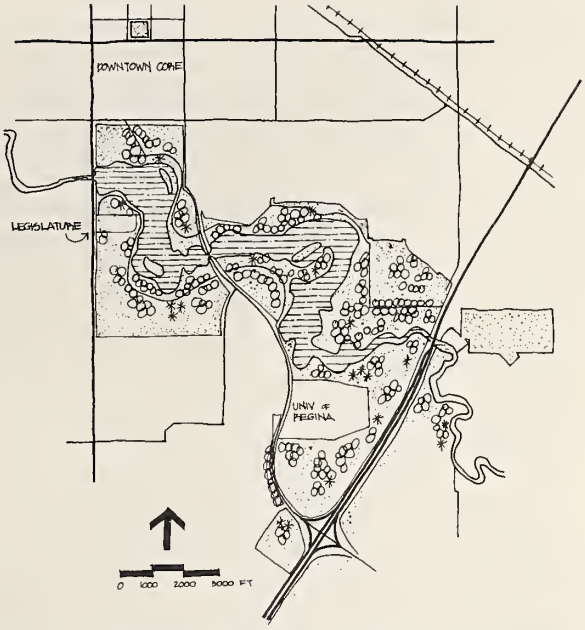


Fig. 2-3. Wascana Centre, Regina, Saskatchewan

filled up with housing developments and shopping strips as farmers and other rural land owners found it more profitable to sell to subdividers than to maintain agricultural or woodlot production. Since there were few municipal or provincial controls on development, land was altered to accommodate the maximum number of lots and to facilitate road and municipal service installation. This often entailed tree removal and the elimination of topographic variations. Wildlife habitats and natural areas were consequently reduced. The automobile often became a necessity for reaching school, shopping and work. Road and parking lot construction accelerated runoff, increased the frequency of flooding and led to stream realignment and channelization, with subsequent loss of aquatic and river-bank habitats. Extensive paving also caused water table alterations, faster runoff of flood waters and the death of mature trees.

In response to such growth pressures, municipalities gradually began to create parks and recreation departments and to develop zoning by-laws which required retention of open spaces. Regional authorities were established to manage flood plains and escarpments, and provincial governments provided more parks within easy travel of major population centres. However, more recently, economic constraints and construction costs have brought a curtailment of many parkland creation programs. As a result, existing open spaces which remain will probably receive added use pressure, and efforts to protect and preserve unusual natural settings may become more difficult and challenging.

2.3 THE CHANGING URBAN ENVIRONMENT

Human impact on natural environments is not new. While some human needs have changed and increased dramatically over time, others have remained relatively the same. It is interesting to ponder whether needs have changed from more basic ones, such as for food and shelter which generally can be accommodated relatively easily in natural environments, to more frivolous and less basic needs. Many of our needs today are satisfied outside environmentally allowable limits. By contrast, during the millenia of hunting and gathering societies, and the early era of cities, most social collective and individual needs were satisfied within environmental limits.

The human psychic relationship with nature has changed as well. Perhaps humans have evolved in their relationship to nature, from a stage where they were opposed to nature ("people working against nature"), to a stage, more recently (but some would argue this) where humans work with an awareness of the constraints and limitations of nature ("people consulting nature"), to a future stage where human activities and welfare are contingent upon the ongoing workings of biological processes ("people cooperating with nature"). The first continuous urban settlements were, from the very beginning, the sites of pollution, disease and of warfare. It seems almost as if people-against-people conflicts are rooted in people-against-environment disharmonies. Are cities perhaps by definition environmentally exploitative? Before the Industrial Era, human impacts on the environment generally tended to be direct. Since the Industrial Era and the rapid growth of cities, the effects of urbanization on natural environments have become so complex and pervasive that the interactions are often very difficult to separate. Through the process of urbanization mankind has created new ecosystems - natural environments with new types of interactions and new scales of human-induced impacts. Natural environments today are increasingly people-moulded, people-controlled and people-dependent. Human-induced changes of the environment tend to occur sooner and more rapidly than do natural processes.

Mankind is simplifying the natural environment: the diversity of nature (its very strength) is being undermined by human intrusion into the biological landscape with large-scale agriculture, including cash crop production and ranching, as well as expansive housing developments, and the application of insecticides, pesticides, and herbicides needed to protect these investments. Preserved natural environments, especially in cities, add to biological diversity and render life safer for both mankind and other organisms. There is very much a biological life-protection rationale for the preservation and safeguarding of natural environments. Yet we cannot prevent urbanites from using these natural environments for outdoor recreation.

From the smallest urban or suburban backyards to the large regional park, the provision of diverse vegetation habitats assures people of greater enjoyment of their surroundings both aesthetically and functionally. For example, a variety of shrubs and trees which flower, fruit, and changed leaf colour at different times (Fig. 2-4) provide a heightened recreational experience and educational opportunity for the participant. Coniferous vegetation (Fig. 2-5) can provide screening against harsh winds, making winter outdoor activities more comfortable, or extending the summer season by forming sun traps. Intelligently placed broad-leafed deciduous trees can shade activity areas on hot summer days, but letting sunlight penetrate during late fall or winter. Diverse plantings have a greater chance of survival should blight or disease occur, while single-species plantings or monocultures are always subject to eradication, necessitating a complete re-planting. Additionally, diverse environments assure shelter for a wide range of desirable wildlife species, including songbirds and small mammals. As natural habitats are encroached upon, those areas which are developed or influenced by humans can become crucial to the survival of many species in and around Canadian cities.

Fig. 2-4. Diversity: coniferous-deciduous mix, native shrubs, perenials, dead tree retained for hole nesting birds and small mammals

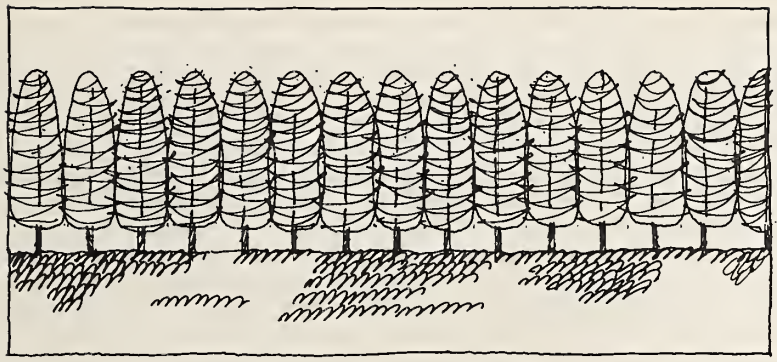


Fig. 2-5. Monoculture. A lack of diversity and interest as well as low habitat value.

Pre-industrial cities were rather small by modern standards and relatively few reached a size of 100,000. City-size was limited especially by technology and the organization of a specific society. In the 19th Century, the metropolis emerged and with it came the outward spread of the urban built-up area. Today, large cities often constitute continuous urban regions which influence all the intervening open land that may still exist between the built-up areas.

These changes have had two main effects on natural environments. First, because densities are increasing across urban areas and are becoming more uniform, it is more difficult to maintain natural environments as public open space. The pressures on open space by competing land-uses mount as all urban land-uses increase in density. Simultaneously, however, the *need* is increasing to preserve natural environments as urban open space. Second, because large cities are continuing to expand, the pressures on natural environments in the outlying regions adjacent to cities is also increasing. The battle to protect natural environments in urban areas, therefore, is being fought on two fronts: to protect "remnant" natural environmentas in the built-up areas themselves, and to protect "front-line" natural environments which are the first to take the brunt of urban expansion on the outskirts of cities. The Regional Municipality of Waterloo's Open Space Plan in southwestern Ontario (Case study 2, page 22), exemplifies an effort to protect such natural resources in a context of increasing development pressure.

2.4 OVERVIEW PLANNING

Planning means many different things to different people. There is a general popular usage of the term, as well as a more specific technical application. At a general level, planning may refer to any future intended action that is thought out beforehand. Thus, any individual or organization has to plan its actions, for otherwise life would be utter chaos. However, the term planning is used here in the technical sense, as a process of intense and comprehensive thought to plan a future course of action, rather than as merely any future directed set of intended actions with some forethought.

Planning is both product and process. The results of considerations of future action will usually be a tangible product of some sort - a plan which may take a number of different forms. The utility of the plan-as-product is that it represents the outcome of the process of developing the future set of actions; without such a product, there would be no, or less, structure to whatever may have been agreed upon. However, the process of planning is of greater importance than is any specific plan which may be devised at a given time.

First of all, no plan is "final". The future is unknown, and any plan dealing with it has to be subject to revision. Thus, planning is a continuous activity, and not activity that takes place only during the time that a plan is being prepared. Implementing the plan is the test of how well the document has been prepared and how efficiently it serves to meet the future. Implementation is the key phase in most organized planning activity.

Planning thus is a process which uses certain defined documents called plans. Periodic review and updating of plans is one formalized method to achieve a balance - in the face of major new trends unforeseen at the time the plans were originally drawn up; however, such reviews themselves may become ritualized and may not truly achieve the desired level of flexibility.

The traditional view of planning is of a linear process of sequential steps (Fig. 2-6). Argument may abound about the ordering of the steps, their specific role, and the timing of concurrent activities. Such linear planning tends to emphasize the final plan-as-product, rather than either the process of how it has been achieved or the process of how it is to be implemented. An extreme, but unfortunately often accurate, view of linear planning is that it results in a document with which planning itself ends - at least in the sense of planning as an on-going iterative process.

Fig. 2-6. Traditional linear view of planning

A different view of planning is one which emphasizes the process more than the plan. Here, the process and products along the way (the plans) are inseparable - they all serve the same function of bettering the social, physical and natural environmental conditions of life (Fig. 2-7). But conflict and competition is rampant in what is believed to constitute "betterment". The process of planning, therefore, must be dynamic to allow adaptation to evolving circumstances and to new understandings of what constitutes a betterment of life. The emphasis in this view of planning is in pluralistic goals and on the interactive nature of the process and those who participate in it.

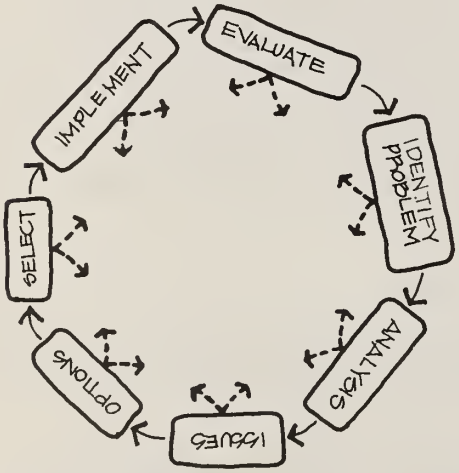


Fig. 2-7. A process view of planning sequentiality of steps exists, be the steps are also interactive

Increasingly, choices in planning are debated among planners and politicians over highly technical alternatives. The shift in decision-making from the political arena to a technology framework tends to mean that the role of the public, and especially groups of activist citizens, may be curtailed. For public groups to be involved and to have a voice, it is essential that their involvement is at the same level of technical competence as is available to the technocrats advising the politicians. The complexity of decisions and the inter-relatedness of information of all sorts, necessitates a technical, as well as a political, environment for decision-making. The shift of politics to expertise changes the rules of exercising power, and alters the structure of previous power networks. As a result, the involvement in planning of people who are ill-equipped to deal with the presentation of issues in a technical framework tends to lag. The effort in planning, as in much of private and public activity, must be directed to balance the demands for increased concern for the unique requirements of local, specialized interest. In the protection of urban natural environments, concern raised by local citizen groups can help to assure that such local interests and local assets are produced.

2.5 ENVIRONMENTAL SENSITIVITY IN PLANNING

The planning of urban natural environments cannot take place in a vacuum outside the general planning of all urban land uses. We may look upon urban natural environments as one land use, which has to be planned within the context of all other urban land uses. But, planning may take place at different levels of sophistication and sensitivity to natural environments. It is senseless to look at the urban natural environments alone, in isolation of the other land uses.

This section outlines a model which will allow one to see how well natural environmental concerns are taken care of within the general land-use planning of any area. Admittedly, the model is an idealized one, but it does form a framework for analysis of any number of local issues that you may be faced with. The terms employed in the discussion which follows were first used by Mr. Mel Plewes of the Ontario Ministry of the Environment. A more detailed discussion can be found in a paper by Dorney and Rich (1976). The four terms define a gradation of planning according to its sensitivity to natural environments. The four levels of environmental sensitivity in planning also outline how planning has evolved and how far planning still has to improve in order to respect environmental concerns.

FLAT-EARTH PLANNING

This approach to planning assumes that the area being planned is basically flat and featureless, and that humans impose on natural environments any designs that may serve their purposes. The result of flat-earth planning have been called the "Roman plague" or the grid-city; a geometric pattern of streets at right angles (Fig. 2-8). Flat-earth planning does not consider variations in topography, soils or geology; climate; water resources and stream hydrology; and plant and animal communities. The process of flat-earth planning implies that nature as such is first destroyed, and is then re-introduced by humans. But the re-introduced nature is people-dependent and ecologically vulnerable. The original natural environment typically is replaced by mono-cultures, such as shade trees, which may take 50 to 100 years to mature. The human-made vegetation and their animal communities, often in nuisance species and numbers, are subject to disease and stress. The main drawback of flat-earth planning is that it is expensive. It may seem cheaper to eliminate nature and to superimpose a human-made design on it, but in the long run the costs are greater than would be the costs of environmentally more sensitive planning. For example, nature's methods of controlling floods, such as flood-plain vegetation and ground seepage have to be replaced artificially, and at high costs, with storm sewers, artificial levees and flood-control reservoirs.

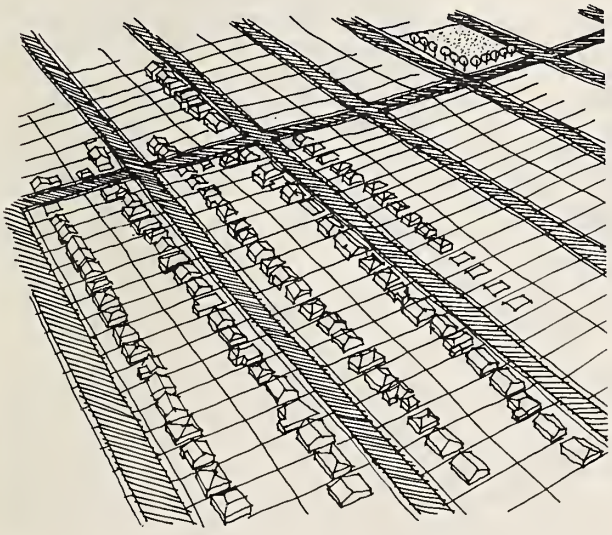


Fig. 2-8. "Flat earth planning": A grid sub-division, with no recognition of topography or natural features. Typical of much post-World War II suburban development in Canada and the United States

CONTOUR PLANNING

Contour planning is marginally more environmentally sensitive than is flat-earth planning. In this type of planning, topography is viewed as the main constraint in the overlay of man's development on a site (Fig. 2-9). The contour map becomes the main (if not the only) "tool" for planning. Contour planning is the state of the art in subdivision planning today. This approach to planning is more sensitive to natural environments only in that steep slopes are not developed and cut-and-fill operations are more limited (needed less) than in flat-earth planning. Vegetation communities are not protected directly, but may be preserved indirectly to the extent that undeveloped steep slopes may be left in natural vegetation. Water-courses may be looked at negatively as a hindrance to more development and floodplains may occasionally be infringed upon to create a few more lots for sale.

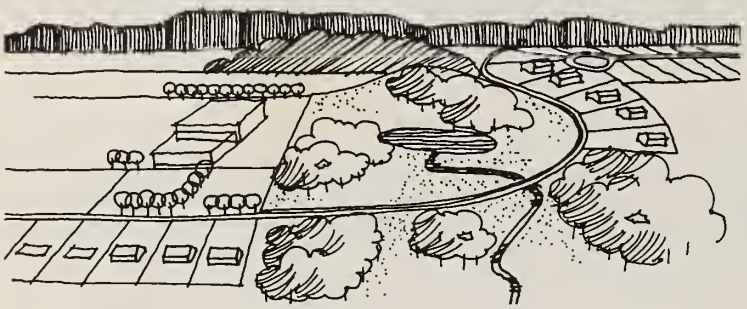


Fig. 2-9.
A step up from flat-earth planning, contour planning recognizes some major natural features or topographic differences. These are often dedicated as park or institutional lands, being unprofitable for housing or commercial development (i.e. wetlands or floodplains)

FEATURE OR CONSTRAINT PLANNING

This level of planning symbolizes a major increase in environmental sensitivity. Physical and other environmental features in the landscape are seen as constraints that must be recognized and integrated into the design for an area. Landscape features and historical aspects are viewed both as constraints and as opportunities (Fig. 2-10).

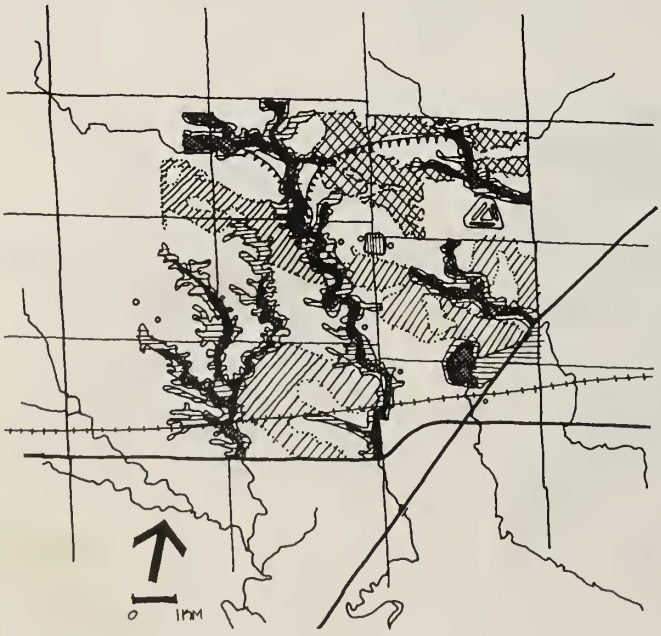
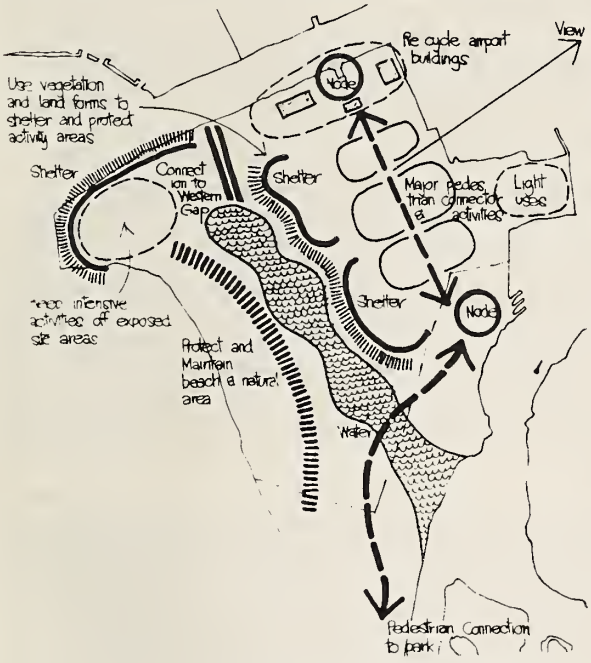


Fig. 2-10.
A constraint composite of biotic and abiotic environmental and cultural components leading to a development plan for Townsend New Town in Ontario (planned by Llewelyn Davis, Ltd.)

The "tool bag" of the planner within the features or constraint approach includes information on contours, soils, vegetation and animal life, historic sites, etc. While the diversity of natural environments is preserved to some extent under features or constraints planning, the main advantage is that ecosystems are being considered and the capacity limitations of natural environments to withstand human use are being incorporated in the planning process.

ECOSYSTEM PLANNING

In ecosystem planning, ecological elements, such as air, energy, water, land and biota, are planned in an integrated way (Fig. 2-11). Ecosystem planning involves recognition of ecosystem structure and function and working with it rather than against it. Ecological elements are viewed as the interacting cultural-historical, abiotic and biotic subsystems. The environment is treated as a dynamic changing system that has evolved from a past landscape to the present one, and will evolve to some future state. The natural successions of the landscape are compared to different degrees of change that development would produce. That is, the ecosystem approach provides a context within which the type or extent of development may be assessed intelligently. The planner's main question is: "If left alone, how would the landscape change (evolve) and what intensity of new human uses may be imposed on the landscape so that the succession of natural systems is still acceptable?" Ecosystem planning adheres to the notion that mankind and nature are in a dynamic equilibrium. It must be accepted that every development has some impact on natural environments. While ecosystem planning helps to deal with these people-nature interactions, it does not answer definitively the question of what degree of impact, or change, is acceptable.



Ultimately, ecosystem planning is cheaper than any other form. The funds invested in the more rigorous planning itself (especially relatively more expensive inventories and field studies) are justified many times over in savings later on. The most economical plan is the most ecologically sensible one!

Fig. 2-11.
An example of ecosystem planning in our urban setting: development strategy for alternate uses of the Toronto Island Airport lands.
(City of Toronto Planning Board)

2.6 URBAN NATURAL ENVIRONMENTS: PLANNING AND GOVERNMENT

Planning takes place at all levels of government. What follows is but a brief overview of the over-all hierarchy, with references to Canadian jurisdictions. Under the British North America Act, municipal government is in the hands of the provinces. The role of the Federal Government in urban natural environments is relatively less important than is the role of the various provincial governments and the municipalities themselves. In the past, the Federal Government had a Ministry of State for Urban Affairs. However, the Ministry was research oriented and, as well, was short-lived. There was also some objection by the provinces to the

Ministry's involvement in various cities, which may illustrate how zealously the provinces guard their jurisdiction over municipal affairs. Paradoxically, however, some Federal election promises made in the past to support urban mass transit and transportation, for example, have not been kept by a party in power.

The Federal Government does, nevertheless, have a legitimate role in urban planning. The Canada Mortgage and Housing Corporation (CMHC) does innovative work in urban planning with a strong housing orientation. The agency's work in children's play environments is of importance to those citizen groups which aim to protect urban natural environments. The Federal role in urban natural environments is also noteworthy, through their involvement in canals, harbours and navigable waterways, particularly in waterfronts, shoreline and coastal areas.

The provincial authority in planning is strongly entrenched in the jurisdiction over municipal institutions, property rights, education, zoning, parks and playgrounds, etc. Perhaps the only major planning area in which the provinces do not have a clear jurisdiction is with regard to large-scale transportation, such as railways and airports. The key to an understanding of municipal planning is the interplay between the planning authority directly administered by provincial departments and ministries, and that administered by the municipalities. The interplay varies considerably from province to province. Fundamentally, however, the ultimate authority rests with the provinces, and it is the privilege of the provincial legislatures to delegate some of that authority to the municipalities. Thus, most provinces have a municipal act and a planning act (called by various names in different provinces) which legally stipulate the authority delegated to municipalities. Significantly, however, final authority usually rests with the province and its ministries and departments. This is illustrated in the discretion a minister has to make a final judgement or the recourse the public may have to appeal boards operated by provincial governments.

The interplay between authority retained by the province and authority delegated by the province to the municipalities is demonstrated in the procedures used to approve various plans for various development, etc. Although the specific steps vary from province to province, initial approvals are generally supervised by a municipality with final approval usually by some higher-level authority in the provincial government. It is common for plans to be circulated for review and comment to all agencies, departments and ministries which may have some involvement in aspects of a plan, or may have its activities affected by what is proposed in a plan. Citizen groups may effectively influence this approval and circulation process, by first finding out which agencies are currently reviewing a plan, and by then presenting their arguments to the appropriate agency, with an aim to influence its comments on and decision about the plan. A group may find little sympathy or cooperation from local government officials, but may find a strong ally in a provincial agency; since the province has final authority, such negotiations with higher level authorities can be effective. Conversely, winning a local agency over to your side is bound to have some influence on higher-level agency decisions.

A significant trend is taking place in urban planning, which influences the provincial-municipal interplay in planning. Traditionally, there has been a two-level system of local government in Canada: counties; and townships, cities, towns and villages - a system inherited from Britain. In Western Canada, there is no direct equivalent to the counties of central and eastern provinces. The general trend, however, is to a new level of government at the regional scale, variously called regional municipalities, district municipalities, etc. Where such new regional governments have been established, the province has delegated substantial planning powers, such as final approvals of specific plans, to the new units of government. In this recent system, municipal plans have to conform to regional plans and the policies made at the regional scale in turn have to meet with provincial approval. Therefore, citizen groups seeking to protect urban natural environments must not be overly discouraged by the distribution of authority to several levels of government.

Not to be confused with changes in local government are the sub-provincial, regional units of administration by various province departments and ministries. There are a number of such special-purpose planning authorities which transcend the

previously described provincial-municipal interplay planning. Such authorities are illustrated by a broad range in scale of jurisdiction, and include conservation authorities, parkway commissions, economic planning units and natural resource management areas. In Ontario, for example, there are the Strategic Land Use Plan of the Ministry of Natural Resources, the Central Ontario Lakeshore Urban Complex, the Toronto Central Region, the Niagara Escarpment Commission, and the Canada Ontario Rideau-Trent-Severn Study area, just to mention a few. Some of these agencies have substantial planning powers, while others are no more than conceptual and often abstract policy bodies. Even though the agencies may be broad in scale, they often include urban areas and may have considerable influence over what happens in urban natural environments. An urban river and its valley, for example, may come under the planning policies of almost every level of government: the Federal government may have jurisdiction over the migratory birds in the valley and over the navigable portions of the river and its harbours or coastal areas used for transportation; the Province may have jurisdiction over wildlife control and timber management; the municipality may control parks and open space land use and development; and a conservation authority may manage the floodplain for conservation and flood abatement. A citizen group negotiating with only the municipal planning department and the parks and recreation department, is limiting its battle to one front; an activist cause can be advanced more effectively if other government levels are also drawn into the battleground.

The protection of urban natural environments may take place at any - and at all - of these agencies' powers of authority. The immediate task for a citizen activist group dedicated to the protection of urban natural environments, is to identify all the levels of government that may have an influence on a decision to be made for a site. Public officials may sometimes not be able to indicate clearly enough what the limitations of their own agency's powers are, and may be unwilling to direct citizen groups to other agencies. Therefore, if a citizens group knows the legislative and jurisdictional maze better than the public or private official who oppose it, half the battle will have been won!

2.7 RECREATION NEEDS

One of the many uses made of natural environments in cities is outdoor recreation. Most people seem to feel that a satisfying life consists of a balance between work and leisure. Leisure time is often spent in the many indoor recreation activities that a city offers, such as theaters and restaurants, or at home. The natural environment open spaces within the city are ideally suited for many outdoor recreation pursuits. Parks and other open spaces near home provide sites where urbanites can spend relatively short periods of available leisure time, such as during evenings after work or during week-ends. How can outdoor recreation needs be identified, and how ought urban natural environments be planned and maintained to satisfy these needs, without large "primary effects" due to urbanization (Jaakson 1977a).

The needs of various subgroups of a larger population are not uniform. As well, needs change over time. An examination of the social composition of a population, therefore, is important in any attempt to plan urban natural environments. Specialists in the field of leisure and recreation commonly deal with socio-economic determinants, and traditionally list them as: 1. population; 2. time; 3. income; and 4. technology. These categories are not needs as such, but they reflect needs: through them needs may be identified. A distinction must be made between need, demand, and consumption. *Need* may be defined as a basic human requirement; *demand* as the activities through which we attempt to satisfy a need; and *consumption* is the actual participation in that activity.

The total population generally has increased more rapidly than has the supply of open space within, or near, cities. A higher total population has also been paralleled by higher densities of urban population and occasional crowding. There has also been a change in the ethnic composition of the population. Most Canadian communities now have large immigrant groups. What are their special needs? Should unique facilities be provided to satisfy their needs? Or, can it be assumed that ethnic recreation patterns will change as New Canadians are assimilated into the

larger society? Many members of different ethnic groups do not follow the recreation patterns of, for example, provincial or national park camping and cottage or resort visitation. Their recreation patterns tend to be more urban-oriented, and rely heavily on parks and other open spaces close to home and in the city. It is difficult to tell if this is by preference or if it is imposed by circumstances such as low income, larger and extended families, and lower ownership of the necessary infrastructure such as cars and trailers.

The age composition of Canada's population is changing. During the last ten or fifteen years, the population had a large young segment, consisting of the baby boom generation. This generation is now moving up through the age-pyramid and as has been documented elsewhere (see Jaakson 1977b) is causing havoc along the way. The pressures on post-secondary education now have become pressures on housing and employment. As the bulk of the population ages, so also change the age-related requirements of that population. For example, since older people may want to use natural environments for more sedentary activities, in the future there may be less demand for sports grounds than for walking and bicycle trails and for siting and contemplation. In a few decades, large Canadian cities may very well have concentrations of older and retired people living in condominium units in relatively dense settings. Lack of ownership of a car (or high cost of fuels) and other constraints associated with age and fixed incomes, will mean that urban natural areas will be used relatively more by older people. Retired people do, however, have ample free time, and the frequency and duration of their use of open spaces may be high. The design of urban natural environments, therefore, should facilitate use by older people: public transit access points, trails with moderate grades, frequently spaced rest areas, and sheltered spots to avoid exposure to the elements.

The changing age composition is not the only population characteristics which will determine the use made of natural environments in the cities of the future. Education levels are changing: a larger percentage of the population now has some post-secondary education. Schools may place more emphasis on leisure education and train people to acquire "life-skills" - recreation and leisure time activities that can be pursued throughout life. Spurred on by the environmental movement and concern for ecology and pollution, people in the future may be expected to use urban natural environments much more for nature contemplation, bird-watching, and other nature-oriented activities. The pressure will be to manage urban natural environments more for intensive use by urbanites.

Occupations also are changing and more people will quite likely have work from which they may seek contrast through leisure activities in the outdoors. Urban natural environments thus will be used by people with an increasing awareness of nature, and with greater knowledge of nature's processes. This may mean that users will be more likely to look askance at deteriorated and poorly managed natural environments, and will be quite vocal with their disapproval.

It is generally accepted that in the future there will be greater availability of free-time. But the future use patterns of urban natural environments will be very different depending on the categories of free time. Longer vacations could mean that long distance travel and tourism will increase. Earlier retirement could give rise to similar trends, or it could result in second and third careers late in life, or major moves to resort communities in warmer climates. But it is also likely that increases in leisure time will come in smaller increments through a shortened work-day and a shortened work-week.

Shorter working hours daily would mean that urbanites have more free time to spend near home during week-days. A shortened work-week would facilitate trips to nature areas surrounding the city during what could in effect be regular three-day week-ends. Thus, a shorter work-day would exert considerable pressure on natural areas within cities, while a shorter work-week would increase the use made of natural areas surrounding cities and in the landscapes between cities. Flexi-time and other employee-determined working schedules would only slightly moderate a tendency for severe peaking in the use made of natural environments. Quite clearly, natural environments will be under increasing pressure. Per capita use of open space can also be expected to increase, especially if the personal ownership of recreation equipment (cottages, trailers, boats) becomes increasingly more expensive for large numbers of wage-earners.

2.8 TYPES OF URBAN OUTDOOR SPACE

The American landscape historian J.B. Jackson observes that although city dwellers now have a greater voice in decisions affecting open space use, a multitude of public agencies must be relied upon for its provision and management. It is, therefore, helpful to survey the types of land available in urban settings, to identify the agencies having jurisdiction, and to suggest what these spaces can offer in terms of natural environmental amenities as well as human enjoyment.

NATURAL CORRIDORS

Riverfronts, ravines, lakeshores, seashores and escarpments are some examples of urban natural corridors. Often, these open spaces are managed by a regional, conservation or other special authority, (Such as, Ontario's Niagara Escarpment Commission). These linear resources provide an unusual chance to maintain the continuity of a region's visual and physiographic character. Corridors particularly lend themselves to recreation activities that require linear routes, such as hiking, cross-country skiing, and cycling. In addition, these resources are often important migration paths for wildlife, thus offering educational opportunities to the entire community. It must be noted here that these corridors are also sometimes attractive to transportation engineers and municipal service planners for economical easements and to the construction industry for economical sources of aggregate (Jaakson 1981). Land developers often view coastal edges and ravine escarpments as profitable sites for luxury homes.

Because of their regional ecological and recreational significance, these corridors require special consideration in the form of sensitive physical planning, management and regulation. Agencies with authority are needed to enforce legislation, conduct project reviews, and to undertake educational programs that encourage public commitment to corridor protection.

The Greater Vancouver Regional District's system of parks serves (Fig. 2-12) as an example of long-range recreation planning which attempts to meet the needs of a growing metropolitan area. Over 16,000 ha have been designated for regional parks in this plan. Each site selected is different, and while some are and will be intensively developed, others are acquired for their wildlife habitat and educational values.

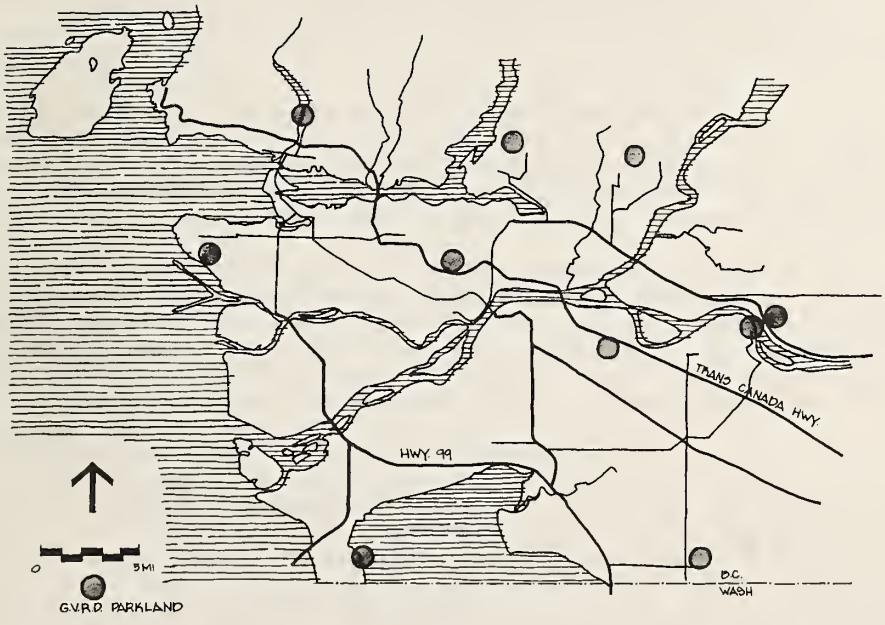


Fig. 2-12. Location of public open space currently managed or under consideration for development by the Greater Vancouver Regional District, B.C.

A second example of regional recreation open space within the urban setting, and on the urban fringe, is the system of conservation areas managed by the Metropolitan Toronto and Region Conservation Authority (Fig. 2-13). These lands include floodplains along the rivers flowing towards Lakes Ontario, and specific land-fill sites along the lakeshore which have been developed for recreation, as well as for erosion protection. These sites offer a range of active and passive recreation opportunities in both summer and winter. In addition, the Authority operates several field centres which provide an intensive conservation education experience for school students throughout the Metropolitan Toronto area and surrounding communities.

Fig. 2-13. Metropolitan Toronto Conservation Authority sites. Most of these places combine recreational and conservation education opportunities with floodplain protection and erosion control.

LARGE URBAN PARKS

Extensively utilized year round, flexible, and easily accessible by foot or public transit, large city parkscapes generally offer a wide choice of human activities, and the opportunity to support varied micro-environments. These parks are also a focus of civic attention and pride. Any controversial change in their management and use usually invites strong citizen opposition.

Formal and informal gardens, specimen tree plantings, wooded slopes, ponds, and wetlands are some of the resources found within such parks. These settings frequently provide the first major contact with the Canadian landscape for many recent immigrants. Most often, these areas are managed by a municipal parks board. Vancouver's Stanley Park, Toronto's High Park and Montreal's Mount Royal Park, are examples of such large urban natural environment open spaces.

Another category of large-scale open space is near-urban parkland. These landscapes are usually managed by regional, provincial or federal agencies, and are adjacent to large population centres. Often, they contain a mixture of terrain including meadowlands, floodplains, steep slopes, and mountains. Mount Seymour and Garibaldi Provincial Parks near Vancouver are extensively used by urbanites. Bronte Creek Park, located midway between Toronto and Hamilton in Ontario, represents a provincial attempt to maintain a rural landscape in an urbanizing context (Fig. 2-14). A steep wooded ravine, a floodplain bottomland, bogs, cultivated farmland and open meadows lie within the park boundaries. A small demonstration farm, nature trails,

Fig. 2-14.
Bronte Creek Provincial Park west of Metropolitan Toronto. An example of a near-urban large park, which also acts as a gateway park to the rest of the provincial parks in Ontario. Parking is limited to the outer rim of the park (indicated with a "P") and there is only pedestrian, bicycle or park-transit circulation in the interior of the park.

picnic areas, and campsites are among the facilities offered. Planted strips buffer the park from industrial development and a major highway. It is interesting to note that one of Bronte's original objectives was to provide opportunities for urbanites of limited financial means. However, a lack of frequent and economical public transportation from either Hamilton or Toronto place it out of reach for most low-income families of these cities.

Another example of a recently developed large urban park managed by a provincial government is Fish Creek Provincial Park in Calgary, Alberta (1975). Currently one of North America's largest urban parks, it is discussed as Case Study 3 later in this chapter.

NEIGHBOURHOOD PARKLAND

Outdoor space at this scale has usually been set aside by a municipality or by private land developers as required in by-laws, The smallest neighbourhood open space is usually the playlot of about 0.1 ha in size. Larger neighbourhood open spaces of 1-2 ha may contain a small playfield, a playground, and passive areas. Still larger community wide scale open spaces of 6-12 ha often contain a recreation centre, athletic facilities, a school site, and passive areas.

There are opportunities at all of these scales of open space to introduce vegetation with educational as well as functional value, and through skillful siting of facilities to create a sense of connection with the larger surrounding landscape. Wherever possible, native plants should be used, with trees and shrubs selected for their flowering properties, seasonal colour, and ability to attract wildlife. The "environmental yard" approach to designing children's playspace (such as that developed and implemented by the California landscape architect Robin Moore) is a way of directly involving young people in the natural environment. On the micro-scale, children are involved in the planting, development and maintenance of natural areas and gardens as part of a creative play process. Hopefully, these people will enter adulthood with a greater commitment to the creation and protection of natural areas within their home communities as well as elsewhere.

It is in the design and use of neighbourhood parkland that the city dweller can exert the most direct influence. Active citizen groups have been instrumental in reshaping the policies of school boards and parks departments. For example, they have been successful in preventing local parkland from being usurped for road widening and for sewer easements, and have helped to obtain better park surveillance and to encourage school boards to renovate hard surfaced yards into creative play environments.

However, as Jane Jacobs observes, successful neighbourhood open space must initially be easily accessible and visible for people to utilize it fully and care for it.

RECYCLED LANDSCAPES AND UTILITY CORRIDORS

As economic and population pressures increase, a thrust to recycle land for recreational and other open space functions has emerged. Quarries, exhausted strip mining operations, sanitary landfill sites, and utility corridors can all be planned and reshaped to serve new functions including the creation of forest areas and wildlife habitats. Some recycled quarries support fish populations, while utility corridors can form part of a regional or local bikeway and trail system. The land beneath hydro corridors need not be a clear cut swarth. Experiments with planting in hydro alignments suggest that these areas can be made visually more acceptable and also provide wildlife habitats. Land below hydro lines and towers in urban settings has also been used for allotment gardens to grow vegetables and flowers.

Rehabilitation requires both skillful design and technical proficiency, as well as a willingness by utility companies and resource industries to incorporate human and natural amenities into their corridor planning. Requiring the mining and aggregate industries to provide rehabilitation schemes and proof of funds as a prerequisite for permit approval is one logical method of assuming that these sites are not left unusable (Jaakson 1981).

Other sites regarding study and replanning are surplus lands left over after industrial development and road building. Freeway interchange construction, road widening and flood control projects have often left unplanted barren land that is unused and unsuitable for permanent occupation. Portions of Toronto's Don Valley (Fig. 2-15) are a notable case in point. A six-lane expressway, access roads, industry, and a rail line cover large parts of the valley. Despite these changes, the Don Valley serves as an important migratory corridor for wildlife, and has been the object of several planning studies aimed at increasing natural amenity and public use.

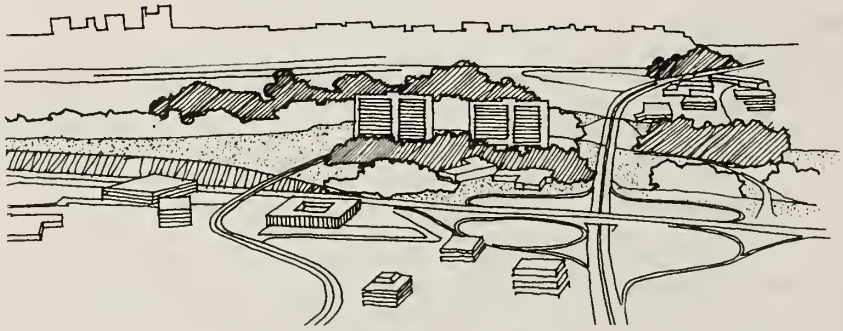


Fig. 2-15. Don Valley corridor, Toronto

STREET AND SIDEWALK ENVIRONMENTS

In many urban and suburban settings, the street and sidewalk are important places of human activity. Despite the potential conflicts between car and pedestrian, children consistently use streets for both play and socializing. Chalk, applied with childhood abandon, transforms hard surfaces into exciting play areas. Street corners and steps often become meeting places for adolescents and adults.

Because the street environment has such social importance, careful thought and management is needed to provide plantings that enhance human comfort and maximize educational potential. While several Canadian cities have maintained their native trees and have embarked upon planting programs, many others have neglected their urban vegetation. Severance of roots, road salt, spray, depletion of the

ground water table, soil compaction, and incompetent pruning, practices have all extracted their toll. Replacement with concrete, sod, and ornamental exotic plant materials have helped to produce bleak landscapes and what Robert Dorney calls "genetic junkyards". Recent budgetary cutbacks for planting in most municipalities also restrict street tree maintenance and installation programs.

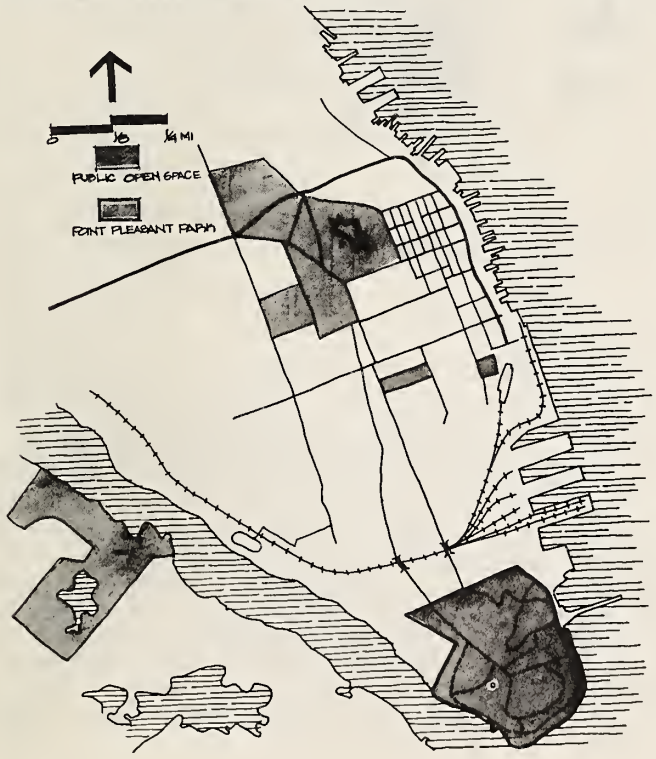
Research and long-term planning are needed to assure that hardy, economical street vegetation is provided. Street plantings that create a sense of continuity with the surrounding natural landscape would maintain ecological consistency and better serve human requirements, as well. Plant lists must therefore be developed which delineate appropriate species for paved areas, commercial streets, and residential neighbourhoods. Residential yards have the potential to act as mini-ecosystems, making these spaces attractive to wildlife and visually more exciting for people.

2.9 OPEN SPACE CASE STUDIES

Four examples of urban open space are briefly discussed in the following pages. Each one is from a different part of Canada, and exemplifies attempts to balance habitat preservation and historical site protection with current and future recreational needs of people in a community and its surrounding region. While some examples have been long established and operate successfully, others are in the early planning stage or still being negotiated. The open spaces selected vary in size from approximately 80 ha to environmental corridors such as escarpments, river flood plains and continuous woodlands, extending over many kilometers.

CASE STUDY 1. MARITIME PROVINCES: POINT PLEASANT PARK, HALIFAX, NOVA SCOTIA

A natural tract of 75 ha reserved for pedestrian use, Point Pleasant Park (Fig. 2-16), is situated at the extreme south end of Halifax with panoramic views of the harbour, the Northwest Arm and the ocean. The park operates under an unusual agreement between the Government of Canada and the City of Halifax. The city provides an annual operating grant and maintains services, in exchange for a nominal 999 year lease from the Crown.



The park contains several historical sites, including the Prince of Wales Tower constructed in 1796 for defence. Several important protected natural habitats occur within the park boundaries, including one of the few natural heather patches in North America. This plant community dates to an accidental release of seeds by a Scottish regiment garrisoned at the site in the 18th Century. A sizeable portion of the park also contains a woodland and quarry pond, with a nature trail established and operated by the Nova Scotia Museum. The park is heavily used the year round, with popular activities that include a supervised salt water beach during the summer and cross-country skiing in winter.

Fig. 2-16. Open spaces in the central parts of Halifax have a strong historical context and serve inner-city residents.

Another noteworthy open space in Halifax adjacent to the downtown core is the Public Gardens. This area dates to the 1870's when Richard Power, a student of the English landscape architect Joseph Paxton, influenced the park's design and subsequently became park superintendent. Although Gardenesque in style, the garden is heavily planted with both native and exotic trees and shrubs, making this space attractive for human use, and a haven for birdlife. Figure 2-16 shows these other public open spaces in Halifax. Unfortunately, a clear pedestrian linkage between these areas and Point Pleasant Park is lacking.

A more recent significant attempt to develop a comprehensive open space and recreation strategy for the Halifax region is the Metropolitan Halifax Area Planning Committee's plan of 1971. The recreation component successfully incorporates into the open space plan McNab's Island, Hemlock Ravine, Long Lake and Chain Lake, as well as a coastal wetland. This Regional Plan (Fig. 2-17) preserves vital open spaces to meet the recreation needs of the city and surrounding suburbs, while maintaining the uninterupted health of essential environmental elements such as a mature hemlock forest and wetlands. A series of maps and strategies prepared under the direction of landscape architect Peter Jacobs, clearly shows the potentials for linking these sites by means of a regional network of trails.

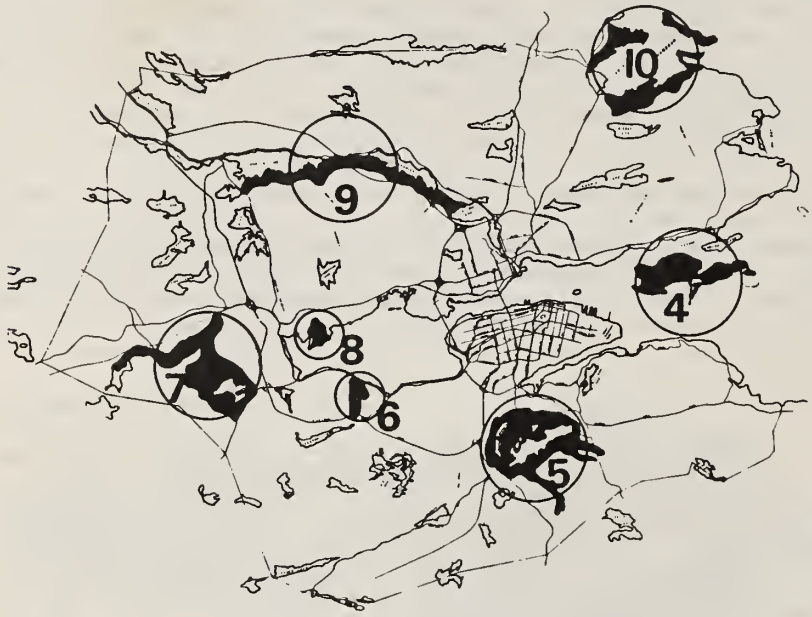


Fig. 2-17. Halifax open space plan: proposed linkages

CASE STUDY 2. CENTRAL CANADA: REGIONAL MUNICIPALITY OF WATERLOO OPEN SPACE PLAN (1975), ONTARIO

The Regional Municipality of Waterloo is located in southwestern Ontario, and includes the Cities of Kitchener and Waterloo. Policies and legislation have been developed to protect almost 70 environmentally sensitive areas and to manage flood-plain lands on the Grand River and its major tributaries (Fig. 2-18).

Based on an environmental inventory and a study of residents' recreation needs, a recommended linked open space system has been developed on two levels. Included is a generalized *regional* network focussed on features, conditions and alignments of regional interest, as well as a *localized* complementary system reflecting community and municipal potentials. Tightly associated with this open space network are approximately 70 environmentally sensitive policy areas (ESA's) which have limitations for development due to their ecological value.

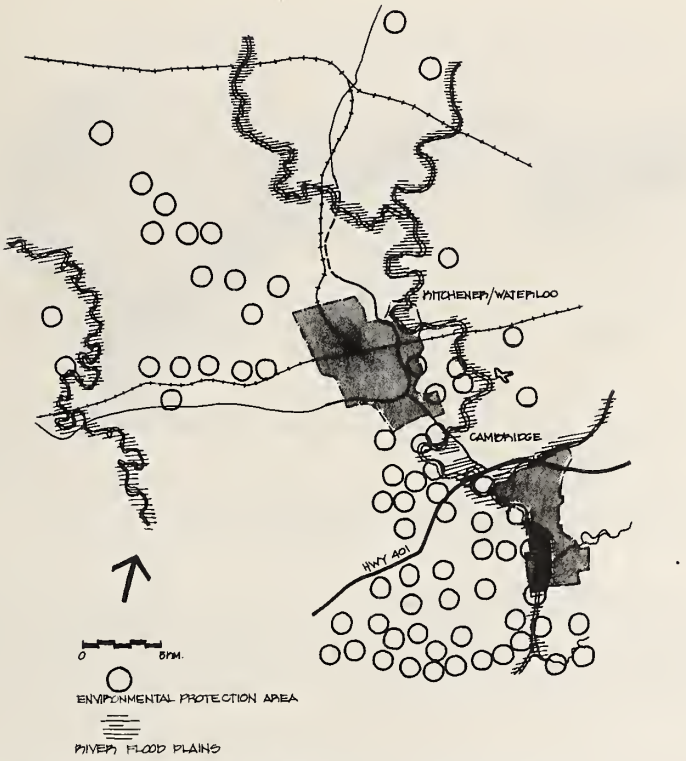


Fig. 2-18. Regional Municipality of Waterloo open space plan

Presently, some strong disputes are being arbitrated between development interests, which claim that the number of ESA's is excessive and that the constraints upon development are too restrictive, and the Regional Government, which wishes to protect these sites.

Some of the open space systems being developed or proposed are:

1. creeks, landscaped storm channels, walkways, and bikeways in urban settings;

2. major natural features such as rivers or elevated ridges, in both urban and rural lands;

3. environmental corridors such as continuous or linear wooded areas, and ecological significant areas with low agricultural potentials;

4. scenic roads and hydro rights of way on the urban fringe.

CASE STUDY 3. PRAIRIES FISH CREEK PROVINCIAL PARK, CALGARY, ALBERTA

Created in 1975, Fish Creek represents Alberta's first Urban Provincial Park. Located on the southeast corner of Calgary, it includes lands on both the Fish Creek Floodplains and adjacent terraces and slopes (Fig. 2-19). It is one of North America's largest urban parks. A citizen's committee was formed to guide initial planning and to gather suggestions from the public. The park contains a protected heronry, a wild garden of prairie grasses, and wildlife which include owls, coyotes, deer and ground squirrels. Despite the rapid growth of the Calgary metropolitan area, the Bow River is esteemed as a major sport fishery for rainbow trout. Unfortunately, the successful continuation of this resource is threatened by inadequate waste treatment upstream. In addition to affording wildlife and plant community protection, this park provides a wide range of opportunities for both summer and winter recreation, and for historic interpretation of the landscape.

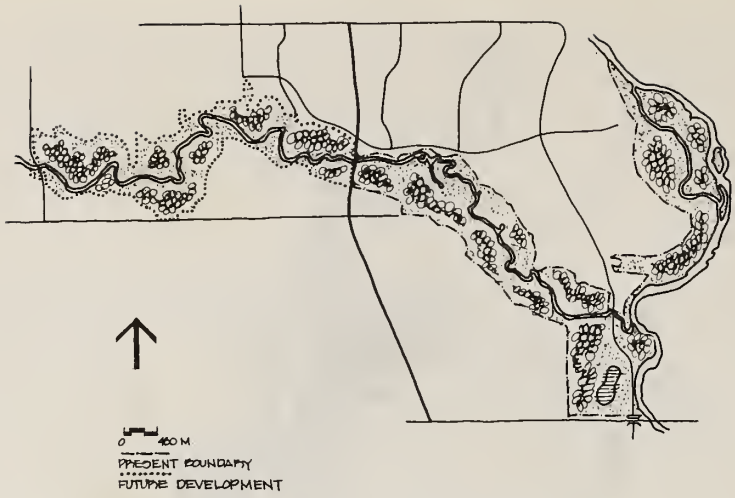


Fig. 2-19. Fish Creek Provincial Park, Calgary, Alberta

Future plans include the development of Silcone Lake and additional land acquisition to the west. These plans also include the extension of regional trails which now span the entire park, and improved bicycle access which would facilitate increased warm weather recreation by urbanites in one of Canada's fastest growing cities.

CASE STUDY 4. PACIFIC COAST: BOUNDARY BAY REGIONAL PARK, 1977
GREATER VANCOUVER REGIONAL DISTRICT

The creation of this regional park involves an attempt to reconcile conflicting demands of wildlife preservation, recreation, agricultural land reserve, and residential development. Located on the south-west side of Boundary Bay, one of the most biologically productive areas in Western Canada which hosts millions of waterfowl during migration, the 144 ha tract of GVRD lands includes intertidal mud flats, sandy shoreline, sand ridges, lowlands, as well as man-made dykes, and pasture lands (Fig. 2-20). These landscapes support a range of vegetation types, particularly those related to a salt water edge ecotones.

The GVRD has argued that an expanded park boundary would permit the restoration of tidal marshes, removal of a man-made dyke, and provide adequate back lands for human recreational use. The concept evolves from strong citizen support for a regional park, the need to preserve deteriorating wildlife habitats, and to expand outdoor recreation opportunities for the rapidly growing nearby communities of Richmond and Delta, B.C. One development alternative under study for this site proposes removal of a dyke, allowing some intertidal flooding to enhance wildlife habitats. The beach would be utilized for recreation, with parking and pedestrian activity kept away from these wetlands.

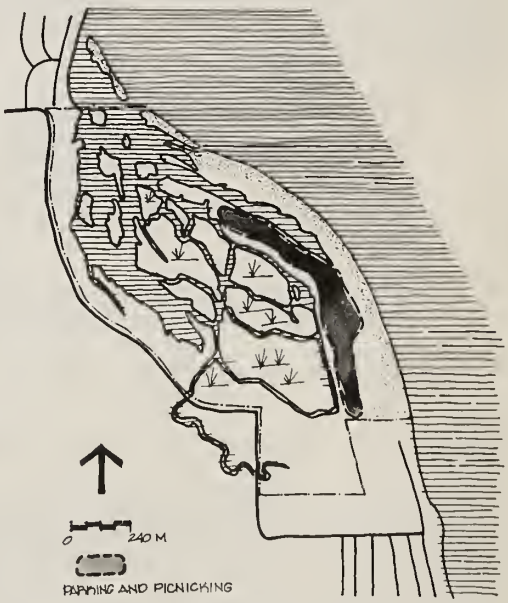


Fig. 2-20. An alternative for Boundary Bay Park, B.C.

2.10 USER-TYPES OF URBAN NATURAL ENVIRONMENTS

Natural environments in and near cities are used by different types of people seeking to satisfy very different personal needs. Presumably, the type of activity preferred by an individual is a reflection of the need that the activity may satisfy for that individual. Natural environments are by no means perceived in the same way, nor are they used uniformly. Differences in perception and use often lead to conflict and competition, although, of course, they need not do so. Awareness of who the main users are, is the first step towards the proper planning, design and management of natural environments.

Users of natural environments may be visualized as consisting of four main types (Table 2-1).

Table 2-1. A simple open-space user-type matrix

	Environmental	Social
Environmental	1 E-E	4 E-S
Social	3 S-E	2 S-S

At one extreme are users who seek exclusively a pure natural-environment experience. At the other extreme are those who seek primarily a social experience, albeit in a natural environment setting.

PURE-NATURE USERS (Cell 1, "E-E", in Table 2-1) seek a totally nature oriented experience. Other concurrent uses detract from their enjoyment. The nature purist is highly intolerant of even the slightest environmental degradation, poor site-design, sloppy maintenance, or intrusion by human-made features. It may be very difficult to manage urban natural environments solely for "pure-nature" users.

PURE-SOCIAL USERS (Cell 2, "S-S", in Table 2-1) seek a totally social outdoor experience. The main attractions are the other users and the interaction with them. The nature setting or the state of the natural environment is relevant only to the extent that it provides a setting and a medium for the overwhelmingly social experience. The needs of pure social users can be satisfied equally well outside urban natural environments.

MIXED USERS (Cells 3 and 4 in Table 2-1) are interested in outdoor experiences where the natural setting provides perhaps the main satisfaction, but where the experience is substantially enhanced by solializing with other sympathetic users. The emphasis may be on the social or on the nature-related experience depending on the user.

It is more than likely that the majority of users fall into the mixed-user category, rather than into either of the two other categories. Yet, the three user types differ significantly enough in their site-use characteristics that different urban natural environments must be set aside to cater to the needs of each group. All urban natural environments cannot be retained in a single state: they cannot all be maintained as urban wildlands, nor can they all be developed for intensive high-density recreation. There must be a gradation of urban natural areas, with some sites set aside for urban wilderness, and others for mixed users. But, how are we to decide which area is to cater to what type of user needs? One approach is to undertake surveys. Even the simplest survey, such as a telephone opinion poll or a short household interview on one or two residential streets, must adhere to fundamental statistical procedures, in order to produce valid and defensible data. A poorly done survey is often worse than no survey at all!

If, on the other hand, your survey uses certain simple statistical procedures, the information can be of great use to advance your case. These scientific procedures increase the likelihood that the results of your survey will be:

1. Reliable: the survey actually measures what you intend to measure.

2. Unbiased: the survey relates to the general population (people in your study area) rather than only to samples of people.

3. Transferable: the survey produces information that may have application to similar situations elsewhere.

The population to be surveyed must be chosen carefully. Do not restrict yourself to, for example, the property owners abutting a proposed high-rise apartment building on a ravine. At the other extreme, do not become too ambitious and define your target population as everyone living within the river basin of that ravine. That is not to say that the environmental impacts of a high-rise on a ravine are spatially limited. On the contrary, the effects may have wide-ranging ramifications. But in terms of a survey, you need to be pragmatic. In some cases there may be a need to define several populations: those most immediately affected, and those more generally (more "distantly") affected, for example. The key point is that each survey needs to be tailored to the population it aims to study.

Having defined your population, the next step is to draw a sample from it. There is no need to talk to everyone. However, there are three basic difficulties:

1. definition of the population: it is important to define accurately the group about which you want to make generalizations;

2. size of the sample: the number of respondents to the survey must be sufficient to give a good range of answers and to reflect the variations in the population;

3. representativeness: the sample must be representative of the population.

The fundamental approach to all sampling is randomness. Generally, a 5% random sample of a population will provide results that are statistically acceptable. For example, you may have decided that the population affected by the proposed high-rise apartment on the edge of a ravine consists of, say, 285 homeowners. A 5% sample than gives you 14 houses where interviews are to be conducted. If these 14 houses are then selected from the 285 in such a way that every single one of the 285 houses has an equal chance of being selected as one of the 14, then the sample is random. Choosing every 5th house would be easy, but it would not be a random sample.

You can use any one of a number of techniques to draw the 14 houses from the population of 285. The easiest method would be to assign each house a number: designate the first house as number one, the last house as number 285. Then using a table of random numbers (many statistics text books will have such a table in an appendix), pick any column of two digits, and read off the first 14 numbers, from the top of the column downward. Ignore all two-digit numbers larger than 285 and ignore all numbers which repeat after your first selection.

Suppose, then, that the selection of 14 numbers in any two-digit column in the table of random numbers gives you: 54, 65, 33, 39, 15, 19, 48, 3, 70, 82, 43, 42, 14, 22 (these numbers were actually drawn). You now have 14 "target" homeowners who constitute your random sample. If you interview them, using a uniform questionnaire, it is safe to say that the results would be statistically not significantly different from the results that you would have obtained had you interviewed all 285 homeowners. If any of your 14 sample homeowners is not available (that is, are not at home at the time you go to interview) then after several repeat visits you may substitute the homeowner on the right, or failing even that, the homeowner on the left.

Once you have decided on your population and drawn your random sample, you are ready to begin the questionnaire. The initial question here will be: should you use a direct personal interview questionnaire, or should you instead use a self-administered mail-out mail-back questionnaire? Your final decision may be based on finances, time and staff resources. Do you have enough people who could competently carry out 14 interviews? Do you have enough time? Keep in mind also that if you mail out the questionnaire to the 14 homeowners, you will not get replies from all of them. If you decide on a mail survey, you could make the decision not to sample at all, and to send a questionnaire to all 285 homeowners. However, mailed surveys are not random and considerably more biased. The opinions expressed by those who return the questionnaire may be significantly different from the opinions of those who did not return the questionnaire.

The main advantage of a mailed survey is that you can cover a larger population; the main disadvantage is that the return rate generally is small and biased and that respondents may misunderstand some questions. The advantage of an interview survey is that you can assure better randomness and can ask in-depth questions; the disadvantages are that your survey may be smaller and possibly more expensive.

In the design of the survey questionnaire, you have a choice between two types of questions, open and closed. Most likely you will use both types. Open questions provide a free answer from the respondent. The respondent can answer the question in his or her own words. The main advantage of open questions is that they are spontaneous, and record the answer in the respondent's own words. Open questions are easy to ask by the interviewer, but they are difficult to record and to analyse, because each respondent will have differently-worded answers. For example, an open question could be "How do you feel about the proposed apartment building on Smith Street?", with several blank lines on the questionnaire page to be filled in with the respondent's answer.

In closed questions, the respondent is offered a choice of alternative answers. Closed questions could be either a two-way simple "Yes-No" type, or multiple-choice. Closed questions are quick and simple to administer and to record, but there is some loss of spontaneity.

Things to avoid in questionnaires include:

- leading questions ("Don't you agree that ...").
- insufficient range of answers in closed questions (always allow for a "don't know" or "other" category of answer).
- presumed knowledge (always check first to make sure the respondent knows something about the issue that you are discussing).
- presumed activity (don't ask "How often do you hike in the ravine?", but check first in another question whether the respondent uses the ravine at all, and if so, for what activities).
- combined question (use two questions to ask about the respondent's attitude, say, to cars, and to aeroplanes).
- too general questions (you may want to make the question more specific. Instead of asking "What do you feel is the environmental quality of Metropolitan Toronto ravines?", ask instead "Last time you visited a ravine, did you see any evidence of over-use?", What was the damage?")
- ambiguous words: avoid such as usually, sometime, good, and fair.

Most likely your survey will not be of a size or complexity to warrant computer data-handling. If you interviewed 14 homeowners, for example, a pocket calculator will be adequate for most data calculations. With all the closed questions, tabulate the results on a master sheet. Then for each closed question, work out the percentage distribution of the answers: the answers to each question should total 100%. However, the open questions will be much more difficult to analyse. Read the answers given to one open question by all the respondents. Write them out on a long list if need be! Is there anything in common to the responses? Do the responses fall into, say, three broad categories (strongly agree, strongly disagree, indifferent)? Write a synopsis of the answers to that question, and quote some representative or recurring comments made by the respondents. In addition to the question-by-question analysis of the results, try to identify general overall patterns in the survey. For example, by comparing the responses to three or four questions, you may identify an important patterns which separate analysis of the same questions would not have revealed.

You must avoid introducing your own personal bias into the interpretation of the survey results. To you chagrin you may find that you personally disagree, perhaps even strongly, with the survey results, or that the results are disappointing. You may find that the survey results give you a clear indication of what action is necessary to rally stronger support for your case. You may have to make an issue

clearer and more generally understood in the community. The survey may indicate that there are rival views within the community, and you may, therefore, have to consolidate your local support before you launch an outside struggle. In conclusion, do not undertake a survey with any preconceived notion of what information it will provide: keep an open unbiased attitude and be ready to change your strategy. But, the survey definitely will indicate to you much better what it is you are up against.

2.11 SUMMARY OF URBAN OPEN SPACES PLANNING

The diversity of urban open space and the range of agencies responsible for their management suggests a need for greater coordination and for open communication. Only in this way will loss of unusual natural resources and open space of community value be preserved. Improved communication will also assure that an informed public is better involved in the decisions of urban land use. Following are some suggested steps that communities can follow to encourage better utilization and management of existing sites and to determine open space priorities.

1. Inventory and mapping of open lands on both the local and regional level. This requires cooperation among agencies such as the provincial ministries, municipal parks boards, and regional authorities. Identification of the characteristics of each space is essential. Information should include size, function, access, vegetation communities and other natural factors, and visual qualities. When this information is clearly mapped at a consistent scale, it will facilitate identification of outstanding natural areas, hazard lands, and the range of opportunities for outdoor use within a community. The existing policies of the relevant agencies also require definition.

2. Identification of the users of outdoor environments. This step may require a questionnaire or random interviews, as well as on-site observation of people and their activities. A key objective would be to determine public attitude toward natural area protection. This activity can be conducted concurrently with the space audit. If a particular area is undergoing conflicting uses, the reason should be determined. Reasons could include lack of user education, unclear policies, lack of regulations, and varied personal perceptions. Understanding user viewpoints and desires also facilitates the development of education programs aimed at securing greater public acceptance of the need to protect particular natural areas from encroachment and to limit human activity within them.

3. Providing space within open space systems. If areas are going to be designated for preservation and limited human use, sufficient resources must be provided that accept a wide variety of activities. Some places will have to be designated for intensive use. Naturalists must realize that in some urban settings, people's exposure to interesting outdoor environments may have to take priority over preservation. For example, it may be extremely difficult to keep neighbourhood children out of a local wetland with fascination as a "secret play space". The social experience gained through the play routine and the incidental education realized through direct contact with bullrushes, mud, and frogs is probably of greater importance than cordoning the area off as an inviolate nesting site. However, educational programs conducted on the community level are essential to gaining awareness of natural amenities and in formulating an attitude of commitment to their inclusion and encouragement.

4. Site specific planning and design. With the stringent budgets faced by the public sector, resourceful design requires greater emphasis. This translates into innovative thinking about neighbourhood streetscape and schoolyards, and park environments that are well detailed and flexible. Plant materials that educate and shelter and require low maintenance should be selected. Sound site planning and design can also alleviate many of the potential conflicts between humans and the natural environment. Intensive use should not include critical areas such as unusual wetlands and dunes where visitors are made to feel like uninvited guests in their own community.

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Landscape Quarterly
Landscape Planning
Urban Ecology

CHAPTER 3

DESIGNATION OF ENVIRONMENTALLY SIGNIFICANT AREAS

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Since the early 1970's growing concern has been expressed over the need to preserve remnant natural areas in Canada. In order to do this, it is first necessary to identify areas that are considered important examples of original natural systems and at the same time are perceived to be especially vulnerable to human use. Since at least 1973 the Ontario Ministry of Natural Resources has been involved in defining such biologically *sensitive* areas, and criteria for their selection have been developed in several municipalities in southern Ontario from 1975 onward (Francis and Eagles 1975; Francis 1977). Experience has shown that the municipal planning framework can be used quite effectively for the protection of environmentally sensitive areas where these areas are not yet subject to the process of urbanization.

This monograph is concerned specifically with natural areas in cities and suburbs. (Examples are given in the three case studies in Appendix 2 of Chapter 4.) However, the general concept can be adapted without much difficulty to urban conditions, and the same criteria can be used, though we have used the term Environmentally *Significant* Area (ESA) since all "natural" areas in cities can be considered to be environmentally sensitive because of their isolation and scarcity. The emphasis, therefore, is best focussed on the environmental significance of a particular urban system, or remnant of one. We suggest nine criteria for rating an area (Table 3-1). The precise way in which these criteria are applied, on a comparative basis, to a number of sites in a region will necessarily vary with the individual character of the region and the sites.

Table 3-1. Criteria for the selection of environmentally significant areas

1.	DISTINCTIVE LANDFORM - The area represents a distinctive and unusual landform within the municipality, province or Canada
2.	ECOLOGICAL FUNCTION - The ecological function of the area is vital to the healthy maintenance of a natural system beyond its boundaries such as: serving as a water storage or recharge area; important wildlife migratory stopover or concentration point; a linkage of suitable habitat between natural biological communities.
3.	BIOLOGICAL COMMUNITIES - The plant and/or animal communities of the area are identified as unusual or of high quality within the municipality, province or Canada.
4.	LIMITED/REMNANT HABITAT - The area is an unusual habitat with limited representation in the municipality, province or Canada, or a small remnant of particular habitats which have virtually disappeared within the municipality.
5.	HIGH DIVERSITY OF BIOLOGICAL COMMUNITIES - The area has an unusually high diversity of biological communities and associated plants and animals due to a variety of geomorphological features, soils, water, sunlight and associated vegetation and microclimatic effects.
6.	HABITAT FOR RARE SPECIES - The area provides habitat for rare or endangered species regionally, provincially or nationally.
7.	RELATIVELY LARGE AREA - The area is large, potentially affording a habitat for species that require extensive blocks of suitable habitat.
8.	ECOLOGICAL EDUCATION OR RESEARCH - The location of the area, combined with its natural features, make it particularly suitable for scientific research and conservation education purposes.
9.	AESTHETIC VALUE OF LANDSCAPE - The combination of landforms and habitats is identified as having high aesthetic value in the context of the surrounding landscape; any alteration would significantly lower its amenity values.

Table 3-1 is adapted from Eagles (1980). Riley (1980) provides a case study of how these criteria can be applied to a particular urban natural system.

A criterion is required to decide what constitutes a regionally rare species of mammal, bird or plant. In the Waterloo Region of Ontario, which is partly rural and partly urbanized, a species known to exist at not more than ten locations (five for the less obvious life forms) is considered to be regionally rare (Eagles 1980). However, because of the scarcity of relatively undisturbed habitat in an urban setting, it would seem more realistic to require three or less locations in order to claim rarity (Riley 1980). The particular definition of rarity (i.e. number of known occurrences over a particular length of time, e.g. three or less in the last fifty years) will probably vary from region to region. However, for any particular region, the *consistency* of the definition is as important as the actual number selected because a constant definition will give a useful rule of thumb.

The compilation of data for judging the nine criteria of even a single ESA can involve considerable work and time. University students working full time under professional supervision on a summer grant can hopefully gather much of the data required, but even then gaps may be left. Local field naturalists are often in a good position to fill these, and to give judgements on the more intangible criteria relating to educational and aesthetic values. In other situations it may be necessary for a local naturalist society to take the lead in organizing an ESA study, working with university or community college students and staff where possible. Guidelines for the activities of such a group, based on a proposal for ESA studies in Metropolitan Toronto, follow.

GUIDELINES FOR A GROUP PROJECT FOR
THE DESIGNATION AND PROTECTION OF ENVIRONMENTALLY SIGNIFICANT AREAS

1. OBJECTIVES
   (a) to carry out the study of significant natural areas in . . . . . .
   (b) to persuade the appropriate authorities to adopt the areas identified as ESA in the official plan

2. METHODS
   (a) Biological aspects:
   - organization of the study group
   - definition of criteria to be used and guidelines for rating ESA
   - identification of specific areas for study
   - development of management guidelines
   - monitoring of human activities in and adjacent to the areas

   (b) Planning aspects:
   - communication with politicians and government staff regarding the value of ESA's and the potential means of protecting them
   - communication of government activities and programs to naturalist group
   - communication of recommendations from the group to politicians and government staff
   - development with government staff of effective and politically acceptable techniques for protection of ESA's
   - educational activities directed towards the general public
   - monitoring of activities in adjacent areas

Smaller remnants of natural systems within an urban situation may be of outstanding value as "reservoirs" of mammals and plants, and corridors for bird migration. Although they may be too small to qualify as environmentally significant areas they are very important in their local settings both ecologically and for use by human beings for contemplative recreation. Concerned citizens and field naturalists can play a leading part in the preservation and management of these remnant systems by making a short study aimed at influencing a municipal council, a planning department, a parks department and the local voters. For example, the Toronto Field Naturalists produced eight ravine studies between 1973 and 1978 which contained a simple biological inventory of plants and birds, information on land ownership and jurisdiction, signs of environmental deterioration, as well as recommendations for future management. The studies were aimed at the layman. The areas studied were already suffering from environmental damage, or were threatened with damage from imminent development.

At a different level, two studies of ravines were produced by university students working on a summer grant in collaboration with a few local naturalists. (Rosedale Ravines; Cedarvale Ravine; Scrivener and Taylor 1978; Gotfryd and Smith 1980). Two other studies of interest were undertaken jointly by a provincial ministry and university students, funded by a private company (Rouge River; Grenadier Pond; Wainio *et al.* 1973; 1976). These were much larger in scope and contained detailed biological data, as well as sketch maps, plans, a questionnaire on human use, etc. Such studies are likely to have an impact at official hearings and tribunals. In another category stands "Calgary's Natural Areas: A Popular Guide", compiled by the Calgary Field Naturalists' Society (Sherringham 1975). This is a first-rate publication and can serve as a model for the kind of natural areas guide that each major city in Canada should publish. Although this book does not contain information on the arguments used by the Calgary naturalists to get these areas preserved, some information can be found in reports of the Society's Natural Areas Committee under the chairmanship of Dr. C.D. Bird of the University of Calgary (Bird 1974).

Another approach can be found in "Toronto the Green" which contains an inventory and maps of the urban natural systems (mostly "remnants" of systems) in Metropolitan Toronto and some adjacent areas, but without biological inventories, though containing a chapter of recommendations for the conservation and management of these areas. This booklet was published in 1976 and it now requires considerable revision because of the rapid alterations to natural systems continually being caused by man in a vastly expanding city complex.

The main point is to make a start as soon as possible, rather than wait until circumstances overtake you. Nearly all cities in Canada contain fragments of important natural ecosystems, most of which are threatened with environmental degradation and loss of aesthetic qualities. If not now, when? If not you, who?

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- Study No. 6: a steep and narrow ravine in public ownership which until now has escaped significant environmental damage, 1977.
- Study No. 7: a valley mainly in public ownership which has been spoiled in two places on the crest of the valley by building development in spite of a public hearing, 1978.
- Study No. 8: a section of a major river valley, ecologically valuable, but continually under threat of construction of a main highway across this section of the valley, 1979.

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CHAPTER 4

STRATEGIES FOR POLITICAL ACTION ON ENVIRONMENTAL ISSUES

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4.1 INTRODUCTION

This chapter contains information on how concerned citizens can play a more effective part in preserving natural areas in an urbanizing situation. It offers practical advice on the various steps which they can take in order to preserve natural areas which are already subject to environmental deterioration, or are likely to be damaged or destroyed in the future.

The chapter also provides information on the political framework within which citizens must operate, and practical advice on how to influence political decisions about environmental issues. Section 4.3 outlines the government system through which laws can be changed, and shows how various levels of government are involved in environmental matters. *The information in this chapter will need to be adapted to the administrative structure and the regulations in particular provinces, cities or urban regions.*

4.2 THE POLITICS OF AN ISSUE

Let us assume that, as a concerned citizen, you wish to make known your concern over an environmental issue. How do you set about influencing those who make the decisions in these matters? What follows is a suggested strategy for achieving your objectives. The steps outlined will not necessarily be taken one by one in the order given; they should, however, be interrelated in a total strategy.

BEFORE AN ISSUE ARISES

Whenever possible, start preparing *before* an issue arises. Check to see if there is an official designation of environmentally significant areas in your community (see Chapter 3). Then make a quick survey of the natural areas in your own city or region, decide which ones you particularly wish to see preserved and in what order of priority, then start to make at least a preliminary inventory of the one you consider to be the most important or vulnerable (see Chapters 7-9). Make an assessment of its overall ecological state, note already existing environmental degeneration and prepare tentative recommendations. Once the study of this natural area is progressing acceptably, try to get three or four people, assisted by students if available, to start the same process in area number two on your list.

Do not try to act alone; act in cooperation with others who share your concerns and objectives. Small *ad hoc* groups usually find it difficult to influence issues. If possible you and your neighbours, or a small group of like-minded people should try to work through, or in close collaboration with, a local Resident's Group, a coalition of Residents' Associations, a Field Naturalists' Club, a Federation of Naturalists' Clubs, or some other established group which has a local base, experience, funds, continuity and clout. (For suggestions on how to organize a group see Appendix 3.)

Before you become too involved with the details of an issue, it is a good idea to hold a couple of sessions in order to work out your goals and objectives within a policy framework. For instance, if your group wants to preserve certain natural areas "in a natural state", it is essential to have an idea of what you mean by "natural state". This is particularly important in an urbanizing environment where nothing exists in a truly natural state and where everything is continually undergoing change. Therefore, at this early stage, examine your assumptions and the arguments that you intend to use. Do they "hold water"? Also try to think out what the objectives of other interest groups are likely to be, and the kind of arguments they may use in facing an issue.

Having done this, you can then define your own position clearly, so that you all know exactly what you are trying to achieve. It is vital that you should all agree on this. Then develop a policy statement on environmental protection and the conservation of natural areas which can be used as the basis for any written submission or verbal statement whenever an issue arises in the future. At this stage it is good policy to start approaching any experts whom you may have living in your locality, such as university or college teachers, and others with special qualifications relevant to environmental issues. Such experts may be invaluable later if you need to call expert witnesses at a formal government hearing.

Also, if possible, before you become involved as a group, make an effort to understand the full implications of the issues involved, both local issues and ones of wider significance. *Local issues* may be caused by the threat of public or private development. Public development may occur in the form of public works construction and maintenance. Issues can also arise from the "management" of a natural area by a public agency when, from a naturalist's point of view this conflicts with sound environmental principles. These are immediate issues. *Wider issues* may relate to laws and regulations governing land ownership and use, policies of government departments and agencies and other aspects of the wider planning process. They may also be related to the lack of public awareness and understanding of the significance of environmental issues. There are long-term questions which require extensive cooperation with various environmentally concerned organizations.

Narrow parochialism is fatal to the objectives of naturalists' groups because urban natural systems do not end suddenly at a local political/planning boundary. What happens in a new subdivision on the outskirts of a built-up area may well have adverse effects on the quality of a river downstream from a development. Do not turn a blind eye to proposed developments just because they are located outside your immediate area of concern.

Instead, watch out for any signs of the "thin end of the wedge". For instance, one new subdivision may be just the beginning of a program of wholesale development proposals. In the same way the granting of permission to one private homeowner to alter the contours of a ravine or river valley slope may result in neighbours following his example, resulting in the permanent damage of a natural area which, until then, was a stable and pleasant natural feature. But in deciding what action to take, you should examine your own motives in comparison with the motives of other people, and decide how to present your case in the best possible light. Decide what argument will carry most weight with local politicians and civil servants, and with the local citizens.

If you are living in a smaller but growing town, you will probably find that you are beginning to lose some of your best natural areas. Do not permit this process to continue without a fight. Otherwise the next generation in your town/city may find that it has few natural areas for enjoyment.

YOUR INITIAL REACTION TO AN ISSUE: DECIDING YOUR STRATEGY

While your group is developing a policy statement and making a biological inventory and ecological survey of the natural area which comes first on its list of priorities, it is quite likely that you will suddenly discover that unknown to your group, plans already exist for a development project or the rezoning of a piece of land in one of the natural areas which you have identified. If carried out, such a development would, in the opinion of your group, substantially reduce the ecological diversity of the area and consequently lessen its environmental quality. You are forced to act quickly and may not have time to carry out the procedures outlined in Chapter 7, 8 and 9. Whether you are ready or not, you are now going to be involved in direct confrontation with other individuals and groups. However, before an issue reaches this stage it may be worthwhile making contact with the developer to see whether it is possible to come to some agreement with him so that the environmental quality you want to preserve can, in some way, be safeguarded. But you will have to proceed carefully in how you sound out the developer's intentions.

At this stage it may be best not to put all your cards on the table, but simply to discuss your concerns with the developer and try to discover whether he is prepared to be flexible. If the proposed development is a public one, you can obtain information on why it is considered necessary, and what stage it has reached, from the appropriate local government authorities. In this case the decision may be a political rather than a bureaucratic one, and you will then have to look for political allies.

Preserving a natural area is not something which can be carried out by naturalists alone, however important their ecological arguments may be, and however detailed are the biological data they have collected. Preservation can only be achieved by a strong community effort involving people with various professional skills and abilities - planners, civil engineers, landscape architects, lawyers and others. The requirement is to "link up with others".

You need to identify other groups in the area which are likely to be adversely affected by the proposed development, even though they may not share your concerns directly: for instance, homeowners downstream from a new subdivision, or homeowners affected by the building of an industrial complex in the watershed of a valley, or people living in a watershed likely to be affected by the development of a sanitary landfill project through pollution or the alteration of the water table locally. Naturalists should also remember that they are not only involved with the biological environment. They are also involved with the human needs and uses, and human life-styles and problems within a city or urbanizing region.

It is important, therefore, to decide which approach is likely to be most effective in any particular situation. Thus, you may consider it best to start with a low-key, behind-the-scenes approach, working through one or more of the other groups already taking an active part in the same issue. However, be prepared to take the lead at some future point if the leading group tends to "back off" too much. On the other hand, you may decide that your only chance of preserving a valuable natural area is by taking the lead from the beginning and confronting the proponents of development head on. But if you take this course, you must realize that you may have to confront people with whom you differ very strongly. In the course of various public hearings you are likely to feel strong emotions, and your own peace of mind will be upset.

Once you become involved in a battle over an environmental issue, you are really involved in a conflict of values, one which involves people's lifestyles, their priorities, and their financial needs and aspirations. At the root of all this lies a cultural conflict, with all the latent causes of hostility which ordinary citizens find so upsetting. Taking an active part in public hearings of this nature is not advisable for those who become easily upset.

Those who are professionally involved in local government, both politicians and civil servants, are mainly involved in "development" processes. Local decision-makers are continually being pressured by developers and by those who need more housing and services. The naturalists' case for preserving a specific area has to be balanced against the case of those who want more and better roads, or more sub-divisions with all the public services which such subdivisions require. You must face up to the fact that, to quite a number of those in government, your case may not seem as strong as it does to you.

Those whom you have elected to political office are under conflicting pressures. You may possibly have members of your group who are politically active and who will know the record of local politicians on environmental issues. If so, they can advise on the best method of gaining the support of at least some of the politicians. If a local election is due to take place while you are preparing a statement of your group's environmental policy, make sure that you send each candidate a questionnaire on his or her position on environmental quality and certain specific issues. (For more on elections see Section 4.3.)

In order to tackle an issue, you will need to know how the machinery of government works - the powers and duties of various ministries, departments and agencies (sometimes overlapping or even conflicting), and their attitudes and records

with respect to environmental interests. You may find that a particular issue with which you are concerned falls within both local (say municipal) and broader (say regional) jurisdictions. (For information and guidance on this subject see Section 4.3.)

Having now prepared psychologically to tackle an environmental issue what are the next steps?

PREPARING YOUR CASE

If the issue relates to private development of any kind, for example, a proposal to rezone valleyland to permit housing, or a proposal to cut down a woodlot for a similar reason, or a proposal by an individual homeowner to cut down the natural vegetation on his or her lot which extends down the side of a stream slope to permit the building of a swimming pool or garage, thus altering the contours and causing erosion, then:

1. Contact you local alderman/councilman before making any formal moves so that he or she has a chance to know of your objections and the grounds for making them. He/she may be able to give you advice; but be careful, as in all your informal contacts, not to show all your cards at first. If the alderman appears lukewarm in his/her outlook on environmental issues, his/her advice may be misleading.

2. Register written objections with the Planning Department and other appropriate bodies in the name of your group, stating your reasons for opposing a development in terms of environmental deterioration, and, if appropriate, on grounds of visual disharmony as well.

If the issue relates to a "public works" project of any kind, such as a proposal to run an arterial road alongside a river valley or down the centre of a ravine, or to build a highway across a wide valley when, in your judgement, the need for such a highway at that point has not been sufficiently proved and has been supported only by a feasibility study, then:

3. Contact your town engineer or public works department, obtain all the relevant information, including maps, a copy of the feasibility study, desirability study or environmental impact assessment, if one has been made, and study them in relation to your own knowledge and perceptions of the environmental issues involved. It is important to find out the current status of a project so that you know what stage it has reached and what the next stages are likely to be, and when. Normally public works departments are unable to give exact information on the status of a project; sometimes, if a public agency is keen to carry out a particular project, its officials may deliberately be vague about its current status. In this case you will have to adopt a multiple contacts strategy, and piece together the status of a project through a number of sources of information.

Whenever contacting politicians and public officials, be prepared to write or telephone more than once. This is often necessary in order to obtain a meaningful response and build up a sense of "pressure" on an issue. If your alderman is experienced, he/she may be able to help you, but an inexperienced alderman, although he/she may know about private development issues, may not be able to get any clearer information on public projects than anyone else. In this case you will have to find an experienced member of council who has a good record on environmental issues. There are some sources for information on the interests and records of your local council members, but you will need to ask Residents' Associations and consult newspaper files in order to get such information. When a major public works project has been proposed, such as a parkway belt or a new electricity grid, especially if it is part of an official plan for a metropolitan region or other regional government, it may be difficult to influence the outcome except by bringing considerable and sustained pressure on your elected representatives through strong public opinion.

4. Think very carefully about your objectives and the order or priority in which you place them. Begin by pressing for your optimum position, but be prepared, if necessary, to negotiate. Therefore you need to decide what your minimum acceptable position will be.

5. Study the objections of other interest groups to the project. Then use your environmental arguments to complement their objections, which are likely to be based on rather different grounds. If you are using arguments based on environmental considerations, then stick to them. Do not try to justify saving a natural area by arguing that it will increase property values in the vicinity. Leave that to the members of ratepayers' groups to point out.

6. While preparing your case, look out for precedents or case studies relating to how a particular natural area somewhere else was saved or lost. You can learn useful lessons from case studies and thereby strengthen your own case, and find out what weak arguments or wrong strategies to avoid (see Appendix 2 at the end of this chapter). You may be able to find precedents which fit your particular issue quite well by working through back issues of newspapers or naturalists' newsletters and journals.

7. While looking for precedents also look for laws to support your case (see Sections 4.3 and 5.3). Civil servants are normally good sources of information. However, you should respect their desire to remain anonymous. Professional people at universities and community colleges with expert knowledge may be willing to give special advice, but do not expect them to help you more than casually, or as local concerned citizens, unless you are prepared to pay them a professional fee. Now a word of warning. Experts may disagree professionally over issues. Do not overplay your reliance on the opinion of experts so as to leave your case discredited if there is disagreement among professionals.

Even the smallest campaign you and your friends may want to wage will cost money. It is surprising how small expenses such as photocopying, postage, and film processing can add up quickly to a sizeable sum. All too frequently, battles to save natural areas hinge on your side's ability to hire competent lawyers and expert witnesses to maximize the good points of your case and to poke holes in the opposition's defence.

There are a number of ways to raise money and these are limited only by imagination and time. But first, form a financial committee to set a budget for your campaign. The committee should then establish ways to gather funds. Some methods are: door-to-door canvassing; appeals for donations from local ratepayers groups, businesses, and foundations; fund-raising events such as carwashes. Some of these events can generate good press for your cause (Young 1981). Donations should be carefully accounted for and donors thanked.

USE OF THE MEDIA

Before using the media to publicize your case, you should seek advice from experienced politicians or other people with a political background, in order to judge the right moment at which to make your case known to the public. If you need to get allies early in the campaign, appealing through the media is a useful way. But once the media give coverage to your group or coalition of groups, you will have to face criticism through the media of your position by groups which oppose you. Also the media exposure may cause the issue to accelerate more quickly than you expected. Therefore, once you have gone to the media, you should be prepared to cope with whatever develops.

Once you decide to use the media, make sure to coordinate your actions through one of your members designated to act as liaison with the media, and then keep up the pressure. Send letters to the newspapers. Hold a press conference at which you can explain your position rationally, supporting it with ecological data and environmental arguments from the point of view of both the natural and the human environments in an urbanizing area. Hand the press a resumé of your statement, and

keep a copy for your files. Be prepared to have a representative speak on a radio program or appear on televison. Notify news editors of newspapers, T.V. and radio programs of upcoming events to be held by your group, such as the sending of a deputation to a council meeting.

Another good idea is to lead a publicly advertised walk through a threatened area and invite members of the media to attend. Point out the ecological damage likely to follow from proposed developments in a natural area. Give slide presentations on the area to local groups, to the local council, in public libraries, and in schools. But, again, a word of warning. Be careful not to overuse the media, with the result that you alienate a hitherto favourable, or at least uncommitted, number of citizens.

In addition to these actions, you should be ready to send representatives to hearings of government bodies of various kinds to make prepared statements on your behalf. This, however, is not a substitute for earlier informal contacts with key politicians. Also send letters, but not identically worded, to local political representatives from alderman/councilman upwards to members of the provincial legislature. You can make this task less of a chore by sharing it among various members of your group or association and helping them with the form in which the letters need to be written.

WRITING A REPORT

There are various kinds of reports, briefs and presentations which may be made with the object of preserving natural areas. The kind of report that you aim to produce will vary according to your objectives, and the size and expertise of your group. Here are some examples:

1. A report designed specifically to press for the designation of Environmentally Significant Areas. The criteria for this kind of report are suggested in Chapter 3.

2. A "brief" designed to persuade decision-makers and voters, and to provide information (and a viewpoint) for the media. Such a report is mainly concerned with strategies for political action on environmental issues; it need not be long, and it may focus mainly on the preservation of a natural area because of its value for human enjoyment (aesthetic appreciation, contemplative recreation, etc.), though it should also explain clearly why the area needs to be preserved in as natural a state as possible, and suggest how this can be done. On the ecological side, a good case can be made based on the following information:

   a topographical map of the area; a basic vegetation map; annotated lists of species of flora and fauna found in the area; notes on the abundance and distribution of rare or otherwise particularly important species, with the areas of their occurrence mapped. A list of notable features such as rock outcrops, land subject to flooding, historic points, old trees; information on property ownership and administrative jurisdictions of government bodies; residents' perceptions and concerns. This should not be beyond the scope of local field naturalists working under guidance of one or two professionals.

3. A critique of a proponant's report written for an environmental impact assessment hearing (Chapters 6 and 9 refer).

4. A "technical" report designed mainly for a major confrontation on environmental issues at a hearing before a government body or tribunal when "the other side" will certainly be calling their own "expert" witnesses. This kind of report is based on data collected in ways described in Chapters 7, 8 and 9, and set out as described in Chapter 10. Knowledgeable local field naturalists can play an important part in the collection of data while working in cooperation with professionals.

It is worth remembering that a citizen group may act effectively simply by questioning the evidence of environmental "experts" at a public hearing, because of their own detailed knowledge of the local distribution of plants, birds or fish, over a period of time. For instance, a firm of environmental consultants which employs someone with little local field experience to make a list of flora and fauna, but expects him/her to complete the job in a few weeks in November or March is likely to have its list ridiculed when it is compared with the far more detailed lists compiled by experienced local field naturalists.

Finally, when you have written a report, it is vital to use it to the fullest advantage. This entails making a list of those to whom it should be sent with a covering letter asking the recipient to read it and inviting comments. Do not forget the media. Keep some copies in reserve for the moment when your issue suddenly "boils up" and then use them to the best advantage.

CHECKLIST OF ACTION ON AN ISSUE

1. Before and issue occurs

- Form a group to work on a natural area which you feel is of priority concern.
- Prepare a report giving at least minimum information about the value and problems of this natural area.
- Make contact with other naturalists' groups and with local residents' groups.
- Familiarize yourself with the political as well as the natural terrain.

2. During an issue

- Make sure that it is a worthwhile issue and that you have a good case.
- Make your views known at each stage of the issue through public hearings, briefs, and letters.
- Decide when and how to use the media to the best advantage.
- Keep up the pressure but know when to accept a realistic compromise.

3. "Following up" after an issue

- If you "lose", be certain to monitor subsequent development or disturbance.
- Ensure that environmental damage to the area is kept to a minimum and that any special conditions set out in the decision of the hearing are fulfilled.
- If you "win", remain vigilant. Be ready for the next "round".
- Learn from experience.

EVALUATION

After your group has been in existence for some years and has attained at least some of the objectives for which it was formed, it is wise to carry out an evaluation of your work. If your group has lost numbers and the enthusiasm of those who remain is low, it is better to make a conscious decision to terminate the group. Either the group will then die, or it will get a new lease of life to continue, perhaps with new blood among the membership. There need be no sense of disgrace or defeat in bringing a group to an end after bearing the heat of the struggle to preserve natural areas for a number of years. In any case, self-evaluation by the group should be carried out at regular intervals in order to assess its aims, organization, and methods.

4.3 WORKING WITH GOVERNMENT

Successful intervention by environmental groups to preserve natural areas requires a broader involvement in government than that generated by a single issue. Be prepared to spend time on this, hopefully before being caught up in specific issues.

This section provides some information about municipal government that should be useful in most urban settings. It then deals more particularly with processes of environmental protection.

MUNICIPAL GOVERNMENT

Boundaries

Natural areas in or near cities are often in different municipalities. It is surprising how often this simple fact can be a source of confusion.

In some jurisdictions, urban areas also have an "upper tier" of metropolitan, regional or county government exercising responsibilities that have a major environmental implication. The boundaries of single-purpose authorities or districts (water, transportation, recreation, conservation) add further complications.

Familiarize yourself with the municipal geography of your area. This knowledge will pay off! There may also be proposals to restructure municipal boundaries in your area (annexations, consolidation). If so, check to see whether this could strengthen municipal planning controls, especially on the urban fringes.

Municipal responsibilities

The nature of this responsibility varies between jurisdictions, and often by class of municipality within provinces (city, village, township). However, municipal regulation of private land development is a universal practice and municipalities are responsible for a variety of major public works - the two basic threats to urban natural areas. Moreover, quite apart from their substantive powers, your municipal government can be an invaluable political ally in working to alter senior government decisions that are destructive of local natural environments. Winning them over through effective long-term effort can be doubly rewarding.

Municipal powers are exercised through by-laws passed by municipal councils. These powers are based on delegations of specific authority from the provincial legislatures. This authority must usually be precisely grounded in the municipal statutes of the legislatures concerned.

In many jurisdictions municipal capital borrowing and land-use decisions are subject to review and/or appeal at the provincial level, either by the political executive (collectively, or by the minister/secretary responsible), or by some quasi-judicial body such as a municipal board, or by some combination of the two. Adding to the tentativeness of many municipal by-laws is the fact that they are more readily reversible at the local level than is legislation at senior government levels.

It is important to know what powers are exercised by your municipalities, how these are limited by the relevant municipal statutes, and what processes of appeal and review at the provincial level are applicable.

The planning process

Effective intervention in private development issues requires knowledge about the planning process in your municipal setting. The legal basis for such development is the municipal zoning (restricted area) by-laws in effect. In addition, much new subdivision development occurs in land not yet zoned as such, in which case the legal instrumentality is the more flexible and negotiable plan of subdivision, planned unit development (PUD) agreement or the like.

Zoning is a widely used approach to land-use regulation which essentially restricts the use of land to certain permitted uses and to maximum density and coverage. Many private development issues arise out of application for rezoning from developers who have acquired land cheaply on the basis of zoning they hope to change.

It is essential to know whether a more general land-use plan (comprehensive plan, official plan, general plan) is legally and politically accepted in your jurisdiction as the policy upon which zoning and rezoning (as well as subdivision) decisions must be based. If this is so, then zoning decisions must either conform with the plan or, if they do not, an amendment to the plan must precede the zoning decision (in which case there are two important stages of decision-making in the process). If not, join with other interested groups to get such a plan, since, without it, municipal control of private development can be very arbitrary.

Modern municipal planning is just beginning to recognize environmental values. Development, its servicing, and the tax revenue generated by development, have been the traditional preoccupations of municipal government and "planning". This will continue to be a major pressure on municipal government.

Most plans and related zoning simply designate urban natural areas as Open Space or Parkland at best, or leave them with a nominal zoning which in effect "holds" them for whatever comes along. This means that natural areas not in active recreation use (which has some "economic" value) are vulnerable to plan amendments based on competing uses that have some seemingly more compelling economic value (either private development or inexpensive alignments for public facilities).

Try to work with the naturalist organization(s) in your municipality to have your plan amended to include a more precise statement about such areas. This should include an inventory of environmentally significant areas (ESA's), fairly precise mapping and identification of these areas, and policies to protect them based on various criteria which can be ranged against short-term economic arguments (existence of important/threatened ecosystems - not just rare species - land features, scenic values).

Working for recognition of environmentally significant areas in the official planning policies of your municipality can be easier and more effective if there is some formal institutional basis for it. For example, ecological and environmental advisory committees (EEAC's) have been appointed in some Ontario regional municipalities. These volunteer committees provide advice to the regional councils through the planning committees of councils. Such advisory committees have recently helped to bring about a distinct planning status and procedure for natural areas in these municipalities.(Francis 1977).

When established on a permanent basis, an EEAC can accomplish the following objectives:

1. Make the environmental point of view known inside government.

2. Show by constructive action that environmentalists are logical, dedicated, and practical.

3. Keep a watch on almost all environmentally damaging activities in the municipality and prepare counter-measures in advance.

4. Utilize systematically and continuously the considerable professional expertise that exists in a community but which can be difficult to tap on an *ad hoc* basis.

5. Inform government of issues quickly, even before they become public knowledge.

6. Strengthen the hand of politicians and government staff who are sympathetic to environmental and naturalist values.

7. Educate, in a gradual methodical way, the municipal government to these values.

For these reasons it may be useful to devote some of your efforts to the establishment of an advisory committee in your municipality in advance of any major public issues, if possible. The specifics of the arrangements will, of course, vary from one jurisdiction to another.

One word of caution, however. The above is only one focus for environmental influence in the community. It should not be relied on completely because any permanent committee can get caught up in its own set of compromises in order to maintain itself. Effective pressure by various means is needed in specific issues as they arise. On the other hand, it is necessary to respect the strategy required to maintain the effectiveness of an advisory committee inside the government.

It is not possible here to go into details of the processing of various kinds of development applications. This varies widely in any event. One more important point to remember, however, is that public notice of such applications is often limited to abutting owners. It is therefore important to have contacts with ratepayers groups as well as contacts inside city hall to keep abreast of these potential threats. Equally important is to know the last stages of these processes, including appeals, reviews and/or approvals at other levels of government. Remember, though, it is far better to work with your municipal government than against it!

Relatively minor improvements or changes to private properties can also have serious cumulative effects on urban natural areas, especially where there are steep slopes. Most municipalities have a process which allows such minor variances within the existing zoning by-laws, often the responsibility of special committees or tribunals for this purpose, e.g. altering building set backs, allowing construction of a swimming pool, permitting a lot severance. Beware of these minor land-use decisions. They can result in major disturbances to surrounding natural areas and often amount to more than a minor change. When involved in these processes, insist that existing municipal land-use policies be followed if these are environmentally favourable and be prepared to appeal the decisions of these minor land-use tribunals. Also try to ensure that municipal councils and planning officials have made known their natural area policies, or policy intent, to these tribunals in writing.

Public works and the budget cycle

Important dicisions about municipal (or special district) public works are often made long before local people are aware of them. In some jurisdictions such as Ontario, major public works projects are required to conform to the overall land-use plan if it is in effect, and there must be a statement about them in the relevant chapter of this plan (and the various drafts preceding it). This is the first indication of such projects.

The build-up of a serious municipal commitment to a public works project also occurs in the capital budgeting process. Look here, not in the general land-use plan, for projects of relatively minor scale which can, nonetheless, damage or destroy an urban natural area. They first appear in this process when a standing committee of council recommends them in a report which is adopted by the full council. This usually constitutes "agreement in principle". Either simultaneous with this or a little later, the project is then added as an item to the capital program for some future date.

Many urban municipalities now organize their capital works on the basis of a multi-year capital program, beginning with the current year, which is the "budget" year. An item in the capital program for some future year is not yet a final commitment, although it does indeed represent a build-up of commitment in municipal government toward the given project. Commitment is final (in terms of an authorized budget) only when it is voted as a budget item (which still can be up to a year before actual construction begins). Moreover, even as a budget item, the decision can be reversed and the monies not spent. Also, capital borrowing decisions by municipalities are subject to the approval of the voters in many jurisdictions and/or of agencies at the provincial level. Even so, try to keep a watching brief on the municipal capital program (and the plan) so that you may know as early as possible about impending public works projects having potential impacts on natural areas.

Longer-term political strategy

The urban naturalist must be prepared for the pluralist nature of urban politics, in addition to its bias towards development, if he/she wishes to gain credibility in the political system over a long period of time. This is necessary if the goal is to protect large natural systems rather than simply "win" an issue or two.

Many of the points made in the previous section on the politics of an issue are applicable here. There are some further points to be made, however, in the context of developing political influence over a longer period of time.

Pluralism is a politics of compromise. Develop a reputation over the years of being approachable but firm in your main objectives. Be prepared to negotiate! Keep open a line to the development industry and to the major public works agencies. Have a deep and cumulating knowledge of the ecology of your natural areas, so that you know what can be traded off against the demands of urban development. All-or-nothing is sometimes the only answer, and you will have to be tough about precedents and incremental deterioration of environmental values. But you are still in a relatively weak position, so have maximum and minimum positions as far as possible.

Be prepared for shifting coalitions with other actors and for changes in political strategy. Keep a little distance from ratepayer groups, but work in cooperation. Know what political "logrolling" means and watch out for it - you can win when it works your way and start to lose for no apparent reason when it does not. This is a term used to describe a situation in which politicians are "trading" votes with each other on difficult and sometimes quite unrelated issues. For example, one politician may support a development application strongly favoured by some other politicians, not because he/she favours the development (he/she may even oppose it) but because he/she wants their support on another issue. This could be another development application in the area, but it could also be some unrelated issue, such as improvements to services in his/her neighbourhood, or even support for his/her appointment to some position or committee. However cynical this may appear, it is a practical political reality and must be faced. Unless you are well connected politically and can yourself alter the "terms of trade" on several issues at once, your only strategy is to press your own issue until it has sufficient priority to force politicians to take a principled stand on it independently of their trading for support on other issues. Keep in constant touch with potential long-term allies in government, such as parks departments and planning agencies. Over time, they may accept your values and start to count on you as one of their important constituencies.

Explore new techniques as you hear about them or as they come into use, such as environmental mediation and transfer of development rights.

Election strategies. Be prepared to consider supporting candidates, slates or parties in elections and to publicize the environmental record of incumbents. But if your group has a reputation for independence, it is better to avoid such action so as not to risk losing your special position. Try to ensure that the naturalist leadership is not itself seen as politically ambitious (although sometimes running for election must be risked).

Environmental approvals. Increasingly, specialized processes of environmental impact assessment and approval are coming into existence at senior government levels. These may or may not be well integrated with municipal planning and decision-making. Ideally they should be. However, for some time, the special protection they offer, such as it is, will be important because of the development orientation of municipal government.

HIGHER GOVERNMENT LEVELS

Most urban natural area protection issues that you may experience will be decided at a municipal level. You will discover that the higher levels of government - provincial and federal - are reluctant to interfere in what they see

as purely local matters. If you are not getting satisfaction at a local level, it could be to the advantage of you and your group to broaden the issue sufficiently so that you can legitimately involve politicians and civil servants at higher levels.

Understanding government structure and process is a prerequisite to successful intervention in government decision-making. The time taken to study the organizational structures of municipal, county/regional, provincial and federal governments and search out legislation which may be relevant to your cause will save you much energy and frustration. Information such as decision-making flow-charts and public relations write-ups, as well as interviews with civil servants and politicians, can give you a good idea of how the government and individual departments work.

Provinces vary in whether their municipal affairs departments include planning responsibilities (they usually do, but Ontario is an exception) and whether the largest municipalities are included in the municipal legislation these departments administer (sometimes not the case). There may be separate acts and/or even departments for the larger municipalities, so check this. The provincial level usually approves the official, or general, land-use plan and zoning by-law of a municipality but specific changes to these plans or specific projects may be handled only on appeal to a quasi-judicial body at the provincial level such as a municipal board (e.g. the Ontario Municipal Board).

There are many other provincial agencies with responsibilities that can affect the state of natural areas.

The federal government usually looks after those things which are of a national nature such as marine projects, airports and railways. Their projects may have a serious impact on urban natural areas, such as that which occurs in the construction of ports in marshland. Therefore, they are a force to be reckoned with. At the same time federal authorities may be creating urban transportation and other urban related policies which may affect urban natural areas.

Special authorities

Local special-purpose authorities often exist to exercise a public responsibility having an impact on important natural features, for example, harbours, escarpments, and watersheds. The power of these authorities has been delegated from one or more government ministries or departments. They may also have municipal representation on their boards and may also be partially funded by municipalities. The composition of these authorities can confuse their accountability in the eyes of the public, and make them appear to be rather inaccessible.

Bodies such as conservation authorities and harbour commissions often have large budgets for the execution of ambitious programs which can have important impacts on urban natural areas. You need to understand the jurisdictional powers of these government agencies in relation to other bodies and municipalities. What is the source of the agency's funding and direction? Be prepared to go to the top to get your answers. Do not hesitate to ask for a copy of the agency's "handbook" or "compendium of information" describing its organization and functions. Do the agencies have people on staff competent in the environmental field? An environmental input can be very important in the decision-making process. If they do not have a specialist in environmental matters on their staff, make it your business to see that they hire one.

In Ontario, conservation authorities are special agencies set up for watershed management. They operate under the general supervision of the Province's Ministry of Natural Resources. There are currently thirty-nine of them. However, they are usually controlled by a municipally appointed local board. Their mandate is the management of water resources, especially flood control, on a watershed basis. They normally cut across municipal jurisdictions and can, therefore, view river valley problems in a wider ecological context. Also they are usually funded on a joint provincial-municipal basis. With this broad financial and political base, they are capable of acting effectively on environmental problems. Their strong

local ties can be useful in raising local awareness of environmental needs. However, the word "conservation" in their title can be misleading, since their main function lies in flood control,and they have a much stronger record for engineering works designed to channel and straighten rivers and streams than for conserving them ecologically. There are numerous examples of conservation authorities taking dangerous liberties with watercourses (Wainio 1980). In addition, they can be drawn into very active recreational programs as part of the give and take of distributing flood control funding and new projects. Such programs are not necessarily in the interests of natural conservation of the lands and streams so used. It is important, then, to find out which conservation authorities have jurisdiction over areas within your own city and its urbanizing outskirts. The next problem is how to find out in advance what a particular conservation authority is planning, and how to influence its decisions, either through members of the municipally appointed board or through the senior officials of the authority.

In other provinces there are few, if any, such agencies. However, watershed or basin studies and planning can periodically provide opportunities for input from naturalists.

Both the provincial and federal levels of government may have planning and environmental protection legislation which can be of use in the protection and management of urban natural areas. Increasingly, there are provincial environment departments and ministries. Check with civil servants to determine if certain legislation is applicable to your situation, and be prepared to read over other related legislation to see if there is legislative overlap between the various statutes and/or between jurisdictions.

Senior governments often have ongoing studies and analyses of assorted specific issues and areas or watersheds; sometimes there are commissions set up to deal with special problems. Find out what is being done in the urban or rural natural areas field and see if the data gained in these studies can be applied to your problem. Sometimes a study in progress can be altered to include a particular concern of yours. If there are no studies in your field of concern, suggest to your elected officials and civil servants that one be done. If government agencies do not have the time or human resources to do the job, they may fund you so that you may organize a study.

Breaking into senior levels of government should not be a problem once you understand who the actors are in government and which actors relate to your problem. Remember, too, that sometimes your municipal government can be an ally in breaking into senior levels of government. In the provincial government milieu, you should contact your local member of the legislative assembly. He or she should be able to respond to your wishes or action with concrete suggestions as to whom to see and what to do at the provincial level. At the same time, you should ask him/her to go to bat (lobby) for you in dealing with his/her colleagues and civil servants. If he/she cannot or will not cooperate, look for other elected representatives or officials who have a good environmental record. Much the same format applies when dealing with federal elected representatives. Because of the distances that are often involved in communications at the federal level, tell your representative that you want him/her to improve the communications process.

Next to politicians, civil servants are an important source of information and action. Civil servants are often experts in their fields and can given you a good idea of whether or not you will have a reasonable argument and a chance for success. However, do not forget that civil servants have their own interests to protect and these far outweigh yours. So do not be disillusioned or easily turned off by an eavasive civil servant. Civil servants can provide a wealth of information as to various complicated approvals processes, scheduling of these processes, requirements of various departments, and other things which will help you in your struggle. It is unlikely that you can take advantage of conflict between ministries and departments at higher government levels in your strategy, unless you local representative is a member of cabinet. Some ministries/departments may have conflicting mandates, presenting serious obstacles to their helping your cause. While the civil servants are frequently there to facilitate "good planning" of proposed developments, the information they must provide publicly will also help you in your endeavours.

If you feel your issue is important enough to go to provincial and federal governments, you should also examine the potential involvement of non-government special interest groups (for example, the Canadian Nature Federation and Sierra Club) who are concerned with issues of a higher order and have well-established contacts at higher government levels. These may give you valuable assistance and insight into your problem. If you feel you are not getting anywhere with the government in question, it may be helpful to involve the opposition parties. If the issue is important enough and no progress can be made with the government, the opposition will have no hesitation in raising it during the question period. Opposition for a project can come from many quarters but it is useful, sometimes, to have official government opposition to spear-head your drive. This is as a last resort in most cases, however, since it may further alienate the government in office from your own position on the issue concerned.

For a checklist of government levels and agencies with which you may be involved see Appendix 1 to this chapter. For three case studies of environmental issues, and the lessons learned from them, see Appendix 2.

4.4 CONCLUSION

Never sit back, never give up; even if your natural area appears to have been saved, you need to follow up by checking from time to time to see if there has been any change in the position. If, for instance, there is a road allowance marked on an official plan, it will always be open to reconsideration, even if a decision was made a few years ago not to build a road.

No decisions are permanent in environmental matters. The price of environmental quality, especially in an urbanizing environment, is perpetual vigilance. You cannot trust anyone - you can only rely on your own efforts.

Even if a decision goes against your case, do not write off the natural area. Instead, monitor the construction to make sure that it is within the guidelines of the decision. Make recommendations about minimizing the impact on the local habitat and for replanting.

Notify the appropriate authority of any infractions of the conditions laid down for development and to the regional or district office of the Ministry of the Environment.

Remember that everything is fluid. You may lose your cause eventually, even if you appear to have been successful. But on the other hand you may be able, in the long run, to reverse a bad situation.

Above all, try to maintain a long-term commitment to increasing knowledge and appreciation of the ecology of the natural areas you wish to protect and to the educational work that is needed to broaden such knowledge and appreciation in your community. Continually work to change public opinion from indifference to active support through environmental awareness.

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INSTITUTIONS

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Urban Wildlife Research Center Inc., 4500 Sheppard Lane, Ellicott City, Maryland 21043, U.S.A. Publication: Urban Wildlife News (Quarterly).

The Canadian Environmental Law Association, 8 York Street, 5th Floor South, Toronto, Ontario M5J 1R2

The West Coast Environmental Law Association, Vancouver, B.C.

APPENDIX 1

CHECKLIST OF GOVERNMENT AGENCIES AND RESPONSIBILITIES

It will be useful to maintain reference institutional information with respect to your area, since it is necessary to know which agencies have what kinds of responsibilities and under what kinds of legal authority.

GOVERNMENT INVOLVEMENT IN NATURAL AREA "X"

Your Province Your Municipality Natural Area "X"		Land and water related responsibilities (see checklist C)				
Agency (see check-list A)	Legal instruments (see check-list B)					

A. CHECKLIST OF POSSIBLE AGENCIES

PROVINCIAL LEVEL

- Legislature (enacts laws and amends existing law)
- Cabinet (introduces above)
- Ministries or Departments (e.g. Municipal Affairs, Environment, Natural Resources, Transportation)
    - Branches within ministries
- Municipal board(s) (oversees municipal planning and financial actions)
- Hearing officers/tribunals (for various environmental approvals)
- Commissioner or crown corporations (e.g. Hydro-electric)
- Regional administrative districts of provincial government

LOCAL LEVEL

- Municipal organization can be both lower tier such as cities, towns, townships and upper tier such as regions and counties
    - Municipal councils
    - Municipal departments (planning, parks, works, etc.)
- Special districts, authorities (conservation authorities, sewer and water districts, harbour commissions, parks boards, etc. Many of these are a blend of provincial, municipal and inter-municipal appointees, financial and reporting relationships)

FEDERAL LEVEL

- Parliament, cabinet and ministries/agencies of federal government
- Courts (see Chapter 5.4)

B. CHECKLIST OF LEGAL INSTRUMENTS

Statutes - These are provincial or federal. They provide the basic legal framework for what actions can be taken privately and by public agencies in relation to land and waters. Included is the legislation that gives municipalities their powers to pass by-laws. Cities may also have powers through "private" acts related only to the municipality concerned.

Regulations - Many statutes provide for more detailed implementation through regulations. These actions may be taken by a minister alone (orders) or may require a cabinet approval (order in council).

By-laws - The equivalent of statutes passed by local municipal councils or agencies but must be based in powers given in statutes.

Land-use plans/zoning by-laws - Official or general plans, together with more detailed zoning by-laws, usually provide the detailed legal basis for permissable uses (especially in urban municipalities).

Agreements (conditions - Local development or other actions often require specific agreements between private parties and public agencies or between public agencies (e.g. levels of government). These agreements often impose conditions, which among other things can (or should) deal with environmental features where applicable.

Policies - The weakest form of instrument is a declaration of objectives and intent. While this may not be legally binding, it may add to an argument for/against specific actions affecting the environment.

Decisions - All of the above are subject to further interpretation by the court or by quasi-judicial tribunals when actions taken are challenged or appealed. Disputed provisions in statutes, by-laws, agreements, etc. may be squashed or narrowly (broadly) interpreted as a result of a recent decision by such bodies.

C. CHECKLIST OF LAND AND WATER RELATED RESPONSIBILITIES

SPECIFIC AREAS OF RESPONSIBILITY

These can include the following:

- land-use control (planning and development)
- watershed management (overall)
- flood control erosion
- parks and recreation
- fisheries and wildlife
- drainage and reclamation
- landfill and solid waste disposal
- domestic and industrial water supply
- sewage treatment, storm drainage, water pollution control
- other piped or wired utilities, construction and maintenance (gas, electricity, telephone, etc.)
- road construction and maintenance
- nature conservation
- hydro electric power
- irrigation
- navigation and boating
- security and policing
- environmental hazards (spills, leaks, dumping, etc.)
- weed control

GENERAL TYPES OF PUBLIC RESPONSIBILITY

- policy determination
- financial involvement
- licensing and regulation of private actions
- construction and operational responsibilities
- investigation and inquiry powers
- planning and data collection

A table including all of the above would have many hundreds of "cells" and would be impracticable. Instead, develop a selective or simplified table, or maintain a few pages of information applicable to your area for the relevant topics of responsibility shown in the check list (including persons to contact, telephone numbers, etc.).

APPENDIX 2

THREE CASE STUDIES

The case studies which follow provide readers with actual examples of issues that may arise in an urbanizing setting, and the problems encountered in attempting to save three natural systems: a marsh; a woodlot; and a stretch of tidal marshes.

All three cases resulted in unsatisfactory rulings from an environmental point of view, in spite of carefully presented arguments supported by biological data. Readers can draw their own lessons from these case studies. We would like to have given at least one study of an issue that had an entirely successful ending from an ecological viewpoint, but, unfortunately, in dealing with natural systems in urbanizing areas, we have not come across any documented cases.

CASE STUDY 1. RATTRAY MARSH

J.L. Cranmer-Byng
Member of Toronto Field Naturalists

Colonel James Rattray, who owned an estate of 60 ha at the mouth of Sheridan Creek, in what is now the City of Mississauga, on the shores of Lake Ontario about 32 km west of downtown Toronto, died there in 1959. His property consisted of a mansion and gardens, a 20 ha marsh with a strip of beach adjoining it, together with tableland mainly of orchards and woodlands. The marsh was preserved by the Colonel who allowed naturalists to visit it. Sporadic observations from before 1960 show that the marsh sustained a good variety of wildlife.

Shortly after the Colonel's death, the executors of his estate approached the Ontario Government and the Ontario Parks Integration Board offering to sell the property but the Provincial Government showed no interest in acquiring it for public ownership. Local citizen and naturalist groups then tried to persuade the Department of Lands and Forests to acquire the estate for a provincial park. There were good reasons for preserving it intact since it was considered to be the last significant example of the original Lake Ontario shoreline, together with a marsh and forest tableland, remaining between Toronto and St. Catharines. In one respect the marsh is unique. The natural outlet from marsh to lake is frequently sealed by a shingle bar formed by heavy waves which are whipped up by winds from the south east. This bar acts as a porous dam, but the water level in the marsh begins to rise when the amount entering from Sheridan Creek is greater than that escaping through the shingle bar. When the pressure becomes too great, the shingle is washed out causing a sudden drop in the water level. The depth and size of the marsh pond varies independently of the season, and this sporadic action tends to "change" the pond water. In mid-1961 the Parks Integration Board turned down the proposal, arguing that the area was too small for a provincial park, that it was entirely within one municipality, that it would be difficult to develop as a park, and that it was too near Metropolitan Toronto. This decision was a realistic one but in retrospect it is a pity that the choice appears to have been between a provincial park, with all that this implies, or nothing at all; that some other way of preserving the marsh and its surrounding land could not have been devised at that time, for instance, as a conservation area.

About this time a developer, Mr. Clemens Nieman, made a purchase offer to the trustees of the Rattray estate. Various subdivisions were being approved in that area, and the Township of Toronto had zoned this land for residential development. Eventually the developer, Rattray Park Estates, bought the land in January 1963 for the sum of $425,000.00. Again, in retrospect, concerned citizens might have been more successful in preserving the marsh if they could have organized sufficient public pressure at that time to have the zoning of the property changed to either open space or natural area. But in the early 1960's the environmental movement in Canada hardly existed, land-use planning was a new subject, and the general public knew little about land zoning and its environmental implications. Most concerned citizens were not yet prepared to challenge government decisions on "technical" matters such as land-use planning.

However, when Phase 1 of the development plan for the Rattray estate was publicly announced, the outcry was considerable, and in April 1963 the developer offered to sell the entire area to the Credit Valley Conservation Authority for $875,000.00. This was turned down since the land had recently been bought for less than half the price. By the end of 1963 a coalition of groups had gained enough support to persuade the Provincial Government to hear their case for preserving the marsh, and representatives of the Conservation Council of Ontario, the Federation of Ontario Naturalists, the South Peel Naturalists' Club (the local club most affected), the Credit Valley Conservation Authority and other groups made their presentations. In early 1964 the Provincial Government announced that it would pay half of the cost of buying part of the Rattray estate on behalf of the Credit Valley Conservation Authority if Toronto Township would pay the other half. The developer than stated what part of the property he would be willing to sell and on what conditions. But in 1965 negotiations broke down, and in early 1967 Phase 1 began when bulldozers started clearing the slopes around part of the marsh in preparation for building on 114 lots on 25 ha of land. The struggle to preserve the marsh and its immediate surroundings as an ecological whole had been lost.

By this time however, the environmental movement in Ontario was developing and the Rattray Estate Preservation Coalition waged a long battle with the developer (Rattray Park Estates) over Phase II of the development, in which the public and government bodies were increasingly involved. Proposals and counter-proposals were put forward until in 1971 the marsh proper (the pond of open water with its surrounding cattails), about 10 ha in extent, was bought by the Credit Valley Conservation Authority for $225,000.00 which left the developer with 24 ha. The marsh itself could not be considered ecologically viable as a natural system unless it could be protected by buffer zones. After four years of manoeuvering and counter-manoeuvering at considerable cost to the developer and the coalition, the Credit Valley Conservation Authority finally proposed to expropriate the remaining 24 ha. The issue went to the Ontario Land Compensation Board where experts spent a month giving evidence. As a result Rattray Park Estates received the sum of $2,048,000.00 plus costs. This was the most expensive acquisition of land ever undertaken in Ontario, and set a dubious precedent for the acquisition of other natural areas.

In 1977 a Rattray Marsh Technical Task Force was set up consisting of active concerned citizens, field naturalists and a number of professional biologists, with the object of keeping a watching brief over the marsh and working out long-term plans for its ecological management. Since that time the Task Force has been successful in preventing a trunk sewer from being routed across the marsh but had to accept the construction of a small sewage pumping station. With the management guidelines set out (see item 5 in the reading list), it will be able to make a start on a management plan. If the area is degraded by any further construction or human encroachments it will eventually cease to be a living marsh community. That is why the work of the Task Force is vital and must continue indefinitely.

Who won the battle of the Rattray Marsh? The answer, probably, is "no one"; certainly not the marsh. The tragedy is that those who wanted to preserve the marsh in a sound ecological state at the beginning of the 1960's, when the estate was intact, were not sufficiently organized and experienced to be able to bring public pressure to bear quickly enough to have the zoning of land changed to open space, conservation or natural area. Once the developer owned the estate, the marsh was ecologically endangered, a condition from which it may never escape.

FURTHER READING

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CASE STUDY 2. WARBLER WOODS, LONDON, ONTARIO

R. Walters and J. Cartwright
McIlwraith Field Naturalists

Warbler Woods, a 64 ha tract just west of London, is one of the largest natural woodlands in the area. In 1980 it was annexed to the City for development as a subdivision, with 26 ha to be dedicated to the City as parkland, but with many of the most interesting natural areas to be built upon. Up to what point did concerned naturalists and their friends have a chance of saving the entire woods? And what lessons can we learn from its loss?

The steep ravines and rolling hills of Warbler Woods combine substantial numbers of northern plants with a predominantly Carolinean vegetation. It is largely a mature deciduous forest, untouched in this century, apart from some selective logging during the Depression, and is an excellent example of the upland forests which once covered southwestern Ontario. From about 1910 to 1930 prominent naturalists, who knew it as the Golden-winged Woods after the warblers which nested there, used the area frequently and kept records of their sightings. After the war, the woods were acquired by a couple who discouraged visitors. Until a systematic natural areas survey of Middlesex County was planned in 1976, local naturalists had not visited the area regularly since the 1930's.

In 1971, however, a developer obtained options to half of the woods. In 1975 he persuaded Westminster Township to accept annexation of the area to London. At the same time he put forward a housing and development plan in conjunction with the City of London Planning Department. In late 1975, two local residents wrote to the Planning Department to object, but as yet the local naturalists had no inkling of what was afoot.

In June 1976, a member of the local naturalists' club, the McIlwraith Field Naturalists, discovered by chance that the woods had been optioned. The M.F.N. immediately began a natural history survey, conveyed its alarm to the Planning Department, and in January 1977 began a joint campaign with a local ratepayers group, the Byron Association for the Retention of Greenbelt (BARG), to save the woods. While BARG raised money, aroused other area residents through meetings and regular newsletters, and collected information on aspects of planning, transportation and schools, the M.F.N. gathered data on flora and fauna, and managed to persuade the Mayor and some councillors to come for guided tours of the woods.

In April 1977, Planning Board (a mixture of councillors and citizen appointees) passed the developer's plans, but in May, City Council gave a temporary respite by delaying a final decision until September to allow further environmental studies. The developer, thereupon, hired his own consultants and forbade entry to the woods to all members of the M.F.N., in spite of the fact that the M.F.N. brief had specifically asked for time to finish their survey. Even members of two disinterested surveys, the Ministry of Natural Resources Sensitive Areas Reports, and the London Ecological Sites Survey, were only allowed into the woods for one day. In this latter survey, Warbler Woods ranked as the most valuable natural area in

the vicinity of London because of its size, topography, and the number of its rare or uncommon species of flora and fauna. For instance, it has a 15 m American Chestnut (*Castanea dentata*).

The developer's consultants were given prime time at the crucial September 1977 meeting of the Planning Board. Needless to say they found nothing "unique" about the woods. However, they did recommend increasing the area reserved for park-land from 20 to 26 ha (41% of the total area). The anti-annexation forces had about 45 min starting at 11:00 p.m., to persuade a visibly weary Planning Board to turn down the glossy proposal put forward by the developer. A fair and equal hearing at a reasonable hour at the Board's next meeting should have been requested. The case to preserve the woods was not given much attention, and very hastily the members voted for annexation. A week later, after a 2 hr debate, City Council voted 10-7 in favour of annexation and development.

From that time until the scheduled Ontario Municipal Board hearing in April 1979, BARG and the M.F.N. raised funds, gathered information and eventually secured the professional help of a law student and a planner from Toronto. For the OMB hearing the group was also able to draw upon, for no fee, the expertise of a geographer who was senior author of most environmental studies in Middlesex County, and of an ecologist who demolished the methodology of the report of the developer's consultant, as well as calling upon other people who were able to provide detailed information concerning the woods. However, the OMB officers decided to take the developer's report as the factual basis upon which to dismiss the environmental concerns, and they upheld the developer and the City.

What was gained from this experience? First, it was learned that it is better to shape events rather than to react to them. If you have an area worth preserving, the time to start gathering information and photographs is *before* it is threatened. This is the time to start working to get it in the hands of a Conservation Authority, the Nature Conservancy of Canada, or any other body likely to protect it. Having a credible alternative to development for housing or industry makes your case far more convincing at a hearing. Failing this, try to get the land zoned in such a way as to impede developers. At the very least, cultivate people in the immediate area, so that they can let you know as soon as development plans are afoot. By the time it was learned of the developer's plans, the City had largely committed itself.

If a threat does develop, speak to the officials concerned as soon as possible. We missed our best chance by not lobbying Westminster Township when they were approached about annexation. Just after the OMB hearing, the new Official Plan for this Township zoned Warbler Woods as "sensitive". Because of reports which only surfaced during the OMB hearing, we realized we should have spoken to city officials responsible for parks, sewers, public transportation, and schools before the City took an "official" position in favour of development, for then we could have played on their doubts when appearing before the Planning Board.

It is important to gather as many allies as possible, from special interest groups, ecologists, recreation advisors, and neighbourhood citizens. Seek publicity, don't shun it. We won additional supporters from sympathetic newspaper and television coverage in 1977. Even in 1977, although we were fighting from behind, we might have been able to convince City Council to vote against annexation if we had had more allies, a credible alternative for the site, and more evidence to show that city officials had doubts about the development. In 1979, the OMB hit us very hard because we had only approached the Conservation Authority and Nature Conservancy of Canada shortly before the hearing. It is important to win support from at least some of the elected bodies which have to deal with your area. Even though we had two OMB officials who were reputed to be the most likely to respond to environmental issues, their first priority seemed to be to uphold decisions of elected officials. Although we were extremely happy with our law student, he was not treated with the respect given to the four Q.C.'s opposing us. He was never sent a copy of the final decision! Since retaining professionals for an OMB hearing is costly, it is essential to fight the issue at the local level, and have it defeated before it reaches the OMB.

Although we lost Warbler Woods, we gained some benefits in terms of natural areas in the county. The developer's consultants now carefully solicit our comments when preparing environmental assessments of natural areas, even when they have been retained by the City of London.

We certainly would have preferred having all 64 ha retained as a natural area, but the fact that 26 ha will be deeded to the City as parkland is some comfort and gives us a feeling that not all was lost to the bulldozer. Most important of all, we have learned what actions we must take in order to save our few remaining natural areas.

CASE STUDY 3. BEAUPORT FLATS

H. Mead
Club des Ornithologues du Québec

As with any dossier emerging in a contemporary urban society, the controversy concerning the freeway on the Beauport Flats in Quebec City was enmeshed in a broader context both spatially and temporally. The final debate, in 1978, focussed on the construction of the final sections of the freeway on critical tidal marshes. But the problems had their origins in the Circulation Plan of 1968 which first outlined the freeway proposal along with several other major transportation links. A partial resolution of the problems was provided by the completion of the freeway according to a modified plan, during the summer of 1981.

In the present report, emphasis will be placed on the more limited sphere of citizen involvement in the dossier from May 1978 to October 1980. In May 1978, belatedly taking stock of the situation, two environmental groups appealed to the provincial government to halt construction of the freeway in the area centering on the estuary of the Beauport River. Responding to a formal request of the Quebec Association of Biologists, the government agreed to hold public hearings.

The key to the situation was the fact that the Beauport flats, the tidal marshes extending along the north shore of the St. Lawrence River immediately to the east of Quebec City, constituted an essential habitat for migrating waterfowl and shorebirds. This fact was merely the tip of an iceberg, however, as the public hearings brought out, in October 1978.

The basic claim was well-documented in briefs submitted by the Association of Biologists, the Club des Ornithologues du Québec, and the Canadian Wildlife Service. But these and other briefs succeeded in going much further. They integrated the immediate environmental concern into the framework of the impact of the project on the broader urban environment. Some briefs dealt with air, noise, and visual pollution, public access to "the River", the advantages of improved mass transit, the role of the marshes in the overall ecology of the St. Lawrence River in the area, and potential development connected with the freeway. (Some focussed on the conflict between a proposed deepwater port facility filling half the river at the site and the city's tourist industry.) These and other issues turned a "traditional" environmental confrontation into a debate about the conserver society.

The hearings closed with 27 of 30 briefs in opposition to the project; the report of the commissioners to the Minister of the Environment made this near-consensus clear. In November 1978 the Minister announced nevertheless that the freeway would be completed - although he called it the "idiocy of the century" - but only after an impact study removed environmental objections.

Enraged, and sceptical about the study, the groups which had participated in the hearings organized and launched a media campaign which included the circulation of a petition throughout the metropolitan area. The basic objective of the groups was the relocation of the expected traffic onto an upgraded major artery running parallel to the planned freeway, and improved public transportation.

At the same time, many of the groups participated in a second round of public hearings, this time conducted by the federal government on the question of a proposed extension of the Quebec City port. This project was closely related to the freeway plan, as servicing it was one of the major functions of the new transportation system. Again, public opposition was overwhelming, and the result of the hearings was an insistence by the federal government on a far-reaching environmental impact study, accompanied by a suggestion by the commissioners that such a study would simply confirm the claims made at the hearings. With that, plans for the port expansion were effectively shut down for the time being.

In November 1979 the Ministry of Transport of Québec unveiled a revised proposal. While the freeway would be completed, it would be sited along the present shoreline, rather than on the fill which threatened to destroy, in the original plan, the entire estuarine habitat. The revision was immediately contested by the two most powerful mayors in the Quebec Urban Community. It was seen by many of the opposition groups as a tolerable compromise under the circumstances. In October 1980, the Ministry of Tansport announced that it was sticking to its revised plan.

In retrospect, four components of the campaign seem most significant in attaining partial success. First, an impressive amount of basic information was available, including the presentation by the Club des Ornithologues of computerized data covering more than 25 years of observation on the site. Second, a legal framework was available which provided the possibility for the holding of public hearings. Had the government refused to hold the hearings, it is extremely doubtful if the many groups involved would have been able to mobilize the effective opposition which this forum made possible. Third, the fact that there was a community of interest among groups representing a broad spectrum of the population constituted a potentially powerful political force. Fourth, journalists in the area were very cooperative in providing both newspaper coverage on a regular basis, and television and radio interviews and news bulletins when the occasion warranted.

All of these factors contributed to the outcome. In the absence of direct contacts with the various government officials who finally made the decisions, it is difficult to evaluate their respective roles. But the convergence of many factors that were as much the result of circumstance as of planning and vigilance seems to be the dominant characteristic of the debate.

Perhaps the most striking lesson to be learned from the experience is the need for wide-ranging involvement of citizens' groups in local and regional planning. The freeway had been under consideration for 10 years, and construction on the flats themselves, and in the city, had been under way for 8 years, before effective opposition began. It is unlikely that ordinary citizens' groups will ever have the manpower to monitor government (and non-government) planning for an area, but without it, concern and opposition often arise too late to be truly effective.

However, certain legal safeguards, such as requirements for environmental impact studies and for free access to pertinent information, and such forums as public hearings, at least reduce the monitoring and intervening load that would otherwise be placed on groups seeking to forestall ill-advised projects. In the case of the Beauport flats, a preliminary impact study was prepared by the Ministry of Transport in 1977, which called without reserve for the complete and integral protection of the site. It was never made public. Had an impact study been required, much of the controversy could have taken place at its conception, rather than 8 years after construction started.

These legal aids do not, however, remove the responsibility of citizens' groups to evaluate, and if necessary oppose, various projects. But this is an area where public groups are able to function more successfully. With a project defined, with an impact study providing at least a first evaluation, and with public hearings at least possible, a more rational approach to regional planning would seem likely.

In short, the experience with this case makes it clear that a top priority of citizens' groups should be lobbying for legal procedures and safeguards favouring public discussion of the issues.

For further information on this particular issue, consult the following references:

Battures de Beauport/autoroute 440; Tome 1, Rapport; Tome 2, Annexes; Gouvernement du Québec, Service de protection de l'environnement; November 1978. These volumes contain résumes, and the complete texts, of the briefs presented at the public hearings.

Le dernier mille. Dossiers sur l'environnement: Les Battures de Beauport; Club des Ornithologues du Québec, Inc.; janvier, 1979. (out of print). This text contains, in addition to the brief presented by the Club at the hearings, various documents dealing with the preliminary stages of the controversy, and two briefs presented at the time of public hearings on the proposed deepwater port.

Project d'extension du port de Québec: Verbatim; Environment Canada, Bureau fédéral d'examen des évaluations environnementales; December 1978.

Project d'extension du port de Québec: Mémoires; Environment Canada, Bureau fédéral d'examen des évaluations environnementales; December 1978. These volumes contain the transcript of and the texts of the briefs submitted to the public hearings on the project to expand the Québec City port.

Schéma d'amenagement de la Communauté urbaine de Québec: 2 - le concept; Les Presses de l'université Laval, Québec, 1975.

APPENDIX 3

SUGGESTIONS FOR ORGANIZING A GROUP

The precise organization of your group will depend on your objective, your resources and the length of time available before your issue "comes to a head". Thus the size and expertise of your group will depend on local circumstances. The following are suggestions for one way, among others, of organizing a group.[1]

1. WHOM TO INVOLVE

Whenever possible, try to have local citizens, field naturalists and some professionals in the natural sciences working together as a team. If the issue you are facing is a local one, such as the preservation of a small ravine, woodlot or pond, you may not need much organization, though you may find it useful to set up two groups of volunteers: one to collect information and write the brief or report; and the other to undertake community relations by making useful contacts, explaining your case, and making effective use of the brief or report when it is finished.

However, if you have a major issue on your hands, such as the preservation of a river valley and its watershed, saving a marsh from destruction by draining and development, preserving good farmland and woodland from the construction of a "second airport", then you will need to organize on a larger scale. In this case one method that you can try is the following.

Organize your volunteers into two groups, the Fieldwork and the Community Relations Groups.

THE FIELDWORK GROUP

Members of this group are responsible for obtaining the biological and geophysical data, and ecological information which will provide the environmental content of your brief or report. It is helpful if some members of this group have specific expertise, but those with non-professional interests and skills, such as members of naturalists groups and local historians are invaluable. They may well constitute the driving force of this group. If you can find a planner, engineer or lawyer willing to help, make good use of them. University or high school teachers should be approached to see if they would be willing to have their students do fieldwork as part of their class assignments. The kind of information this group will need to collect is set out under "Writing a Report" in this chapter.

THE COMMUNITY RELATIONS GROUP

This group is responsible for mobilizing political support, fund raising, relations with the media, and with local interest groups and government officials. As far as possible, members should be drawn from the local community. Their task is to build an informed base of support for your group locally.

2. HOW TO GET STARTED

Your group will probably have grown out of a small number of concerned citizens such as members of a Field Naturalists' Club or a Residents' Association (or Coalition of Associations) who are the first to react to an issue when it arises. These people can then personally approach others whom they feel will support

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[1]This appendix is based on a section originally drafted for this book by Dr. J.B.R. Whitney, Professor of Geography at the University of Toronto, to whom acknowledgement is made.

the stand your group intends to take. When you feel confident that you have a nucleus of active people, then work out your objectives and your options for strategy in facing the issue. After that, the group should begin to draft a policy statement.

Once you have a clear idea of your objectives, and a preliminary statement of policy, you can judge whether or not the right time has come to "go public" and link up with more people in order to develop a strong community effort. At this point call a community meeting and explain what you intend to do, and why. Keep a list of people who are willing to play an active part in the group, and note their different interests and expertise; do not forget to record their telephone numbers and addresses.

Your next move is to hold a Fieldwork Group meeting to explain the tasks which need to be done, the time schedule within which the group needs to work and the way the work can best be divided among members of the group. If the issue is a major one, involving a large area, and a fair number of people have volunteered for the Fieldwork Group, then you may find it helpful to organize several sub-groups to report on some of the factors discussed in Chapters 7, 8 and 9. In this case, a group coordinator should be elected and someone made responsible for the progress of each sub-group. The group coordinator should keep a close watch to see that the correct information required from each sub-group is being supplied and that each sub-group is keeping to the time schedule. If the study is mainly concerned with predicting the impact of some proposed action, i.e. a highway through a marsh or expressway along a river valley, then in addition to collecting baseline environmental information and predicting environmental change that is already occurring, each sub-group will need to assess how the proposed changes will directly affect its own sub-system, and also how these changes are likely to modify the other sub-systems.

While this is going on, the Community Relations Section can be organizing itself along lines similar to those described above by adapting its functions particularly to the tasks of making the best case to the public for the policy which you advocate.

3. WRITING THE REPORT

When the two groups have made their own preliminary reports, they should each appoint one or two of their group to cooperate in writing the first draft of the report or brief in order to ensure that an integrated version is prepared. This first draft should be circulated to the members of the two groups with a request for comments by a certain date. A final report can then be prepared.

CHAPTER 5

STRATEGIES FOR LEGAL ACTION ON ENVIRONMENTAL ISSUES

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5.1 INTRODUCTION

The purpose of this chapter is to provide a brief overview of Environmental Law within the context of protecting urban natural environments. It is intended to direct your efforts towards the use of legal means for environmental protection. However, the chapter should be read in conjunction with Chapter 4, which provides strategies for political action on environmental issues. *The Chapter does not and cannot provide all the legal information that you may require.* A number of references and sources for advice are indicated for more specific information.

Before becoming involved in a large expediture of time, effort and money, you should determine your objectives, your legal rights, and whether you can afford to exercise those rights.

The following approach has been simplified to include only four steps:

1. determine the relevant facts;

2. decide the desired solutions;

3. determine the legal issues involved;

4. determine the legal costs.

The remarks below will expand on these ideas.

THE FACTS

Before you do anything, enough facts must be gathered to identify the problem. Only then may you begin to look for solutions as well as put limits on the size of the problem. For example, the habitat of a rare species, the blue racer snake, is being threatened, or the enjoyment of your private property is being threatened by a proposed garbage dump, or there are five natural areas in your urban setting which your group believes should be propected. You need sufficient facts to be able to determine whether you have an issue. Once these facts are gathered and you have determined that you have a viable case, you can start thinking about potential solutions.

In addition to environmental data, other factual information will be required. The type of information will depend upon the type of desired solutions. Thus, if the preservation of a natural area is involved, information should be collected as to the ownership of the property, what the zoning by-laws indicate the land may currently be used for, what the official plan states that the present and future uses of the land may be, and whether a provincial ministry or a conservation authority may be interested in acquiring the land.

There are no hard and fast rules about the information that should be collected; it will depend on the nature of the case.

One crucial problem in environmental law is to recognize an issue early enough to have an opportunity to influence decision-making. Thus, if you have gathered information on a natural area *before* a developer has applied for permission to put in a sub-division, appartment building or shopping centre, you will be in a stronger position to influence the final decision than if you are suddenly confronted with an issue without any data. You are still faced with the problem of obtaining early warning of a developer's plans. Aim to make your impact on a decision in the initial stages, when a draft official plan is being circulated rather than when an

application has been made to change the zoning regulations on a property. Once all approvals have been given and the bulldozers have started work, you will find it much more difficult to influence the outcome.

Having gathered the facts, you must define your objective. If you do not know where you are going, it is very difficult to obtain a satisfactory solution, particularly with legal issues. There are many approaches. The solutions you seek should be based upon your objective. Thus, if your objective is to stall a development, a lengthy hearing may be sufficient. If your objective is to preserve a natural area, one of the following strategies may apply:

1. purchase by a conservation authority, a provincial agency or other body;

2. a hearing before an administrative tribunal;

3. a court action;

4. a political solution.

You may have a choice amongst several alternatives, or there may be no satisfactory solution. However, it is pointless to look for solutions if you have no clear-cut objective in mind. Also, keep in mind that your objectives, as well as your hoped-for-solution, may change as you learn more about the law.

5.2 THE LAW

Because of the large number of environmental laws, regulations, rules, guidelines, by-laws and procedures which exist at the federal, provincial and municipal levels in Canada, this section is aimed at assisting the reader to find and use the applicable law, or laws, in his province, municipality or urban region. Additional sources of information and their location are provided at the end of the chapter. The reader is cautioned that these remarks are general and are intended to assist in obtaining the expertise required to deal with a specific problem.

The following overview will indicate the type of legal tools that you may need. Once you are aware of the legal framework that is available, you may begin to find your way through the forest.

BASIC LEGAL PRINCIPLES

The following legal principles are in simplified and generalized form. These principles may provide some understanding of whether the law will be available to help you in protecting natural areas.

1. *Everything is legal unless there is a law making it illegal.*

In a democracy, people are free to do whatever they want unless they are prohibited by common law (which developed in the courts over the centuries); by statute passed by parliament or the provincial legislatures; or by regulation or by-laws passed under statutes. The legality of actions includes all environmental activities such as polluting air and water or developing one's own land without regard to the morality of the issue.

2. *Any freedom can be taken away or changed by government, which has jurisdiction over the matter, by passing a law.*

This includes the so-called fundamental "civil liberties", such as freedom of speech, freedom of the press, and freedom of religion. In Canada, parliament and the provincial legislatures, within their own areas of authority, are supreme. Without a Constitutional Bill of Rights, it is questionable whether there are any limitations on the right of elected representatives to restrict any of our freedoms. Thus, while the first principle stated above means that anyone can destroy the natural areas on his own property, it is equally true that the provincial government,

which has jurisdiction over land-use planning, can pass zoning or development-control legislation restricting use of property, or expropriation legislation allowing government agencies or municipalities to expropriate property in order to preserve it in its natural state. In certain circumstances the federal government may be in a position to control certain areas of land or expropriate certain areas of land. As well, courts have jurisdiction in interpreting and applying common law. The court may interpret an old concept in a new way and thus limit freedom.

3. *The Federal and Provincial governments are not bound by the Statutes they enact unless there is an express provision in the laws stating that they will be bound by them.*

Thus, public agencies that pollute or develop public land may be exempt from pollution and planning laws.

4. *Neither the Federal nor the Provincial government may pass a law unless it has the jurisdiction to do so.*

The authority for parliament or the provincial legislatures to pass laws is derived from the constitution. In some cases, the authority is vested in the federal government, in other cases the provincial government, and in some cases with both. In most land-use cases, the power to make law resides with the provinces. However, certain provincial laws or municipal by-laws may be without force where federal undertakings such as airports or harbour commissions are concerned. Problems in preserving the natural environment may occur where these jurisdictional conflicts exist.

5. *Municipalities are bound by law, and have no power to pass or enforce laws other than under authority granted to them by the Provincial government.*

Unlike the provincial governments and the federal government, municipalities are not an independent level of government. They are an administrative arm of the provincial government, created by statutes passed by the provincial government; their only powers are those set out by statute. For example, they are bound by provincial legislation prohibiting pollution or placing restrictions on development. If a municipality passes a by-law, its officials must comply as must any other inhabitant of the municipality. In Ontario, for example, authority for passing by-laws regarding land-use planning may be found in *The Planning Act*; simirarly, enforcement by-laws such as anti-noise and anti-litter by-laws, may be passed under *The Municipal Act*.

COMMENT

The above principles of law are not exhaustive. Indeed, there is no universal agreement among legal theorists about these principles. However, they represent a good starting point for understanding environmental law.

WHAT TO LOOK FOR IN THE STATUTES

Statute and regulatory material passed under the authority of the statutes is frequently hard to read and difficult to interpret for lay people, and even for lawyers. Nevertheless, when you have found the statute, or statutes, covering your problem and the regulations, rules or by-laws passed under the statutes, you should look for the specific provisions that can help you protect your natural area. Examine the laws carefully to determine what may be of use to you in attaining your goal. Look particularly for the following:

1. *Prohibitions.*

Statutes frequently contain absolute or qualified prohibitions against environmentally harmful activities. For example, some by-laws or development control criteria may prohibit constructing a factory in a land zoned for agricultural use only. Conservation authority regulations may prohibit construction of a building on

a flood plain. Permission may be required from a ministry of the environment prior to constructing a building on the site of a garbage dump within 25 years of closing the dump. Acts, regulations or by-laws may limit the amount of pollution. If an action is prohibited by statute, by regulations derived from a statute, or by a by-law, you can request the appropriate government to enforce the prohibition. Sometimes you can enforce the prohibition yourself through the courts.

2. Criteria that must be met before an action is taken.

Certain acts, regulations, by-laws and development controls require that certain things be fulfilled before action is taken. Some examples are as follows: Is a developer required to notify neighbours before proceeding with a development? Is an environmental impact assessment required before a project can be authorized? Must some percentage of a sub-division be donated to a municipality as parkland by a developer before permission to proceed can be given? Have all applications been filled out providing information about projects? Has the developer proved that his project is in the public interest? If such pre-conditions are set out in a statute, demand that they be followed. If they are not followed, you may be able to challenge the approval of the project, or its construction, in the courts.

3. Public hearing.

Does the statute provide for one or more public hearings before approval is given to a project? If so, direct your efforts towards preparations for these hearings as early as possible.

COMMENT

The statutes provide the ground rules under which a project or an act may or may not be operative. Understanding the ground rules will allow you to be more effective in your representations. Comments which follow will give you a better understanding of the use that may be made of the legal framework.

5.3 KINDS OF LEGISLATION AFFECTING NATURAL AREAS

It is impossible to be comprehensive about the kinds of laws that affect the preservation or destruction of natural areas. However, there are laws passed specifically to protect natural resources and the environment. There are laws passed to regulate various kinds of development. Some of these laws contain provisions to ensure consideration for the environment in the development process and others do not. As well, some of these laws which do provide for the protection of the environment do not provide an enforcement feature in the law. In some areas there is a duplication of laws at different levels of government that may affect the area that you are concerned with. Therefore, you will need to become familiar with the laws that regulate or could regulate the natural area you are concerned about. Here are a few of the categories of law that may affect the natural area you seek to protect.

1. Land-use planning legislation.

Legislated tools for land-use planning include the parks acts, conservation authority acts, provincial planning act, zoning by-laws, development control by-laws, official plans, and sub-division control. Land-use planning tools are described in Chapter 4.3.

2. Pollution control laws.

Every province, as well as the federal government, has a pollution control law that makes it an offence to pollute air, land and/or water and requires licensing of sources of pollution. Recent laws also require people responsible for contamination of the natural environment to clean up spills, restore the environment to its previous condition and compensate the victims of pollution.

3. Natural resources laws

Legislation governing industries such as forestry, mining, oil and gas exploration, gravel pits and stone quarries and the management of similar natural resources usually contains some requirements to take into account the preservation and restoration of the environment. This legislation originates at the provincial level although in areas where there is uranium and thorium mining, there are both federal and provincial laws.

4. Energy Legislation

Provision of energy often has an adverse effect on the natural environment. For example, hydro-electric power developments may result in transmission lines crossing sensitive areas or in damming and flooding vast tracts of land, such as the James Bay project in Quebec. Even solar energy may involve cutting down trees that shade the solar collector. The provision of energy is subject to various laws, for example, laws establishing public utilities, regulating their activities, the Atomic Energy Control Act, and a vast amount of petroleum legislation.

5. Parks Legislation

Every level of government has legislation to establish and manage parkland and wilderness areas. These range from small, intensively used, heavily recreational urban neighbourhood parks to vast tracts of wilderness in remote areas maintained primarily for preservation rather than recreation. Under such legislation, a master plan may be prepared which will dictate the manner in which the land will be used.

6. Wildlife preservation and management

This encompasses a variety of laws including international treaties protecting migratory birds and their habitat, laws protecting endangered flora and fauna and their habitat, laws regulating hunting and fishing.

7. Transportation legislation

The establishment and maintenance of roads, railway lines, airports and flight patterns of aircraft, shipping routes and harbours are governed by specific statutes. Certain aspects of these laws may reside at all levels of government. Transportation of dangerous goods has increasingly become a subject of specific laws including a new *Transportation of Dangerous Goods Act* passed by the federal parliament.

8. Environmental impact assessment legislation

Several provinces have statutes, and the federal government has policies requiring environmental and sometimes social and economic impact assessments of major projects (see Chapter 6.1).

9. Heritage legislation

Most provinces have legislation providing for the preservation of buildings and street scapes of particular historical and architectural significance. Certain acts, such as the *Niagara Escarpment Planning and Development Act* and the proposed plan prepared under that act, protect the open landscape. Provincial heritage laws, as well as specific acts, may be drafted broadly enough to enable the governments to designate natural areas for preservation as well as cultural sites.

10. Drainage

Agricultural and urban drainage projects are often subjected to specific statutory requirements. Drainage may also fall within the regulatory control of bodies such as conservation authorities.

11. Agricultural and top soil preservation laws

These are relatively recent innovations that may be of assistance occasionally. As well, you should be aware that some provinces have policy statements with regard to agricultural land preservation which may be incorporated into local and provincial plans.

5.4 LEGAL PROCEEDINGS

COURTS

Generally speaking, you will need a lawyer to handle a case in a court. There are exceptions such as private prosecution of violations of various statutes or by-laws which may be prosecuted in provincial courts, or actions which may be brought in small claims courts. Many statutes contain provisions which, if violated, provide that the Crown, or you, may lay charges against the offender. It may be that a court will find that the person is guilty, order him to cease and desist from an activity or fine him. In some cases, a court will review the actions of an administrative tribunal and find that there has been an error, ordering that a new hearing be held or making an appropriate order.

Legal action in courts may be the only method by which you can proceed to protect a natural area. If a private prosecution or court action is such that it may be handled by a lay person, it is wise to seek some aid on how to conduct the action unless you have already developed some expertise in this area (Estrin and Swaigen 1978).

The following points should be kept in mind:

1. Courts are more formal than administrative tribunals in that the rules of practice, laws of evidence and decorum are generally more rigidly enforced in courts.

2. Court decisions may well establish a precedent which will protect other natural areas, while administrative tribunal decisions are not necessarily used as a precedent.

3. Courts are often less equipped and less willing to handle or understand large quantities of technical evidence than administrative tribunals.

4. Court costs can become substantial particularly if costs are awarded against you. In Canada a loser often has to pay not only his legal costs but the legal costs of the successful party in an application before a court.

5. You will generally need a lawyer to handle an action in a court.

ADMINISTRATIVE TRIBUNALS

Administrative tribunals have become an increasingly popular forum for governments to review applications under specific acts. The National Energy Board established under federal legislation reviews applications on pipeline routes, as well as other matters. The Ontario Municipal Board hears applications under *The Planning Act* for official plans, official plan changes, zoning by-laws and zoning by-law changes. The Ontario Environmental Assessment Board hears environmental assessments made under *The Environmental Assessment Act*; and garbage dump and sewage plant applications under *The Environmental Protection Act*. As well, hearing officers may be appointed under specific legislation for a specific purpose. An example of this are the hearings of the proposed plan for the Niagara Escarpment under *The Niagara Escarpment Planning and Development Act*. This plan is an environmental plan covering the Niagara Escarpment from Queenston to Tobermory over a distance of approximately 700 km. Each province is likely to have its own variations of certain of these acts.

The type of legislation that establishes an administrative board or tribunal will set out the composition of the board and the type of jurisdiction that it has. The rules of procedure may be set out in part in the Act establishing the board; or under another Act which sets out the subject matter to be heard; or under an Act such as *The Statutory Powers of Procedure Act*; or the board may be allowed to establish its own rules of procedure under an Act which establishes the board (see Appendix A for The Rules of Procedure in the hearing under *The Niagara Escarpment Planning and Development Act*). You must also determine if you have a right or *standing* to appear before the board or tribunal.

Administrative boards or tribunals are probably the most effective forum for you if you do not have a lawyer. A knowledgeable person can often achieve as much if not more than a lawyer before these boards, provided he knows what he wants and how to get it. If you have appeared before a board previously, you will realize that there are qualifications to that statement. To be effective before an administrative tribunal, you must know how to conduct a case before such a tribunal. You are advised to:

1. Contact the tribunal or board in question and ask them for their rules of procedure; you should also spend some time asking the chairman, a board member, or someone on the administrative staff how the hearings operate.

2. Speak to a lawyer who has appeared before this type of tribunal and find out what sort of precedents are important in cases such as yours, what type of evidence is required, how to present the evidence, what type of argument should be used. If you are going to conduct a case yourself, know *how* your case should be conducted as well as *what* your case is about. Proper preparation and knowledge are the key elements to success before any administrative body.

3. If possible, attend a hearing before this type of administrative tribunal to see how someone else conducts a case. Style of presentation is something you will develop. The best way to learn administrative advocacy is to watch other people practice it, to observe what works and does not work, and then adopt methods that may work for you. Some field naturalists who have appeared before administrative tribunals have developed excellent skills in preparing and presenting cases as well as in cross-examination.

4. Consult some texts on preparing and presenting cases before administrative tribunals. See, for example, Roman (1977).

OTHER FORUMS

If you enjoy certain rights, you may need to make representations to municipal councils, or to various civil servants, to request that they change or enforce laws, regulations or by-laws. The types of rights will determine where you should appear to enforce those rights. You may be able to get the government to prosecute your case. The obvious advantage of having someone paid by the taxpayers prosecute the case is that the government will pay for the prosecution rather than you. Similarly, if a level of government will change its law or policy, the end result may be more beneficial.

EVIDENCE

Evidence consists of facts, opinions, and professional opinions. You may be qualified to give professional evidence as well as your own personal opinions. Regardless of the forum that you are appearing in, you should realize that the evidence you are putting forward should be unbiased, accurate, and presented by someone who is professionally qualified to present it. A forester with a Ph.D. will not be able to present medical evidence convincingly unless he has qualifications to do so. Similarly, a professional geologist may destroy his credibility if he says *all* gravel pits are bad and unnecessary. It does your case little good if your evidence is distorted or if the person presenting the evidence is not qualified to

do so. In presenting evidence, "who says it" is just as important as "what is said". The facts that you collect should be collected on the assumption that the methodology will be challenged. As well, the data itself may be challenged as erroneous. Therefore, if you are going to collect data, do it properly. Personal opinion evidence is easier to present - anyone living next to a gravel pit would be qualified to state that gravel trucks are noisy, dirty and unsafe.

THE COSTS

Legal costs could vary dramatically. The ideal solution for a citizens' group may prove to be too expensive to pursue. You should, therefore, explore alternative strategies; there may be one that would yield almost the same results for less money. Where financial support is lacking, strategy and tactics must be very carefully considered. Thus, a case that could be won before the Ontario Municipal Board after ten days of hearings might possibly be avoided by making presentation to a conservation authority and convincing that authority to buy the property. The points to remember about costs are:

1. Some legal strategies will cost more than others. For instance, court costs can become substantial if costs are awarded against you. In Canada, a loser often has to pay not only his legal costs, but also the legal costs of the successful party.

2. The fact that you have a possible legal solution does not mean that it should be *mindlessly* used.

3. Political action, or some other strategy, may be preferable to a legal action.

4. Carefully consider the cost effectiveness of your strategies before you act.

5.5 CONCLUDING REMARKS

A four-point method has been proposed for dealing with legal rpoblems. Environmental law, as in the practice of any law, requires the ability to isolate and recognize an issue, consider what the solution should be, identify the relevant law or laws that will bring about the best solutions, and determine the likely costs.

The path through the forest may not be easy, but on the other hand the rewards are worth the effort.

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(a) Key personnel in federal and provincial departments and agencies, environment agencies and citizens groups (including addresses).
(b) Principal enabling legislation.
(c) Key information sources, libraries, information centres and data bases.
(d) Post-secondary educational institutes offering environmental studies programs (a possible source of information and witnesses).
(e) Current interpretative literature (bibliographies) and audio-visual material (catalogues).
(f) Environmental conferences, expositions and regular events.

FOR ADVICE

1. Contact the Canadian Environmental Law Association, 8 York Street, Toronto, Ontario. They will be glad to offer advice and information concerning your problem, and in certain instances, may actually handle your case for you. Contact organizations such as The West Coast Environmental Law Association in British Columbia; STOP in Edmonton; the Saskatchewan Environmental Society; STOP in Montreal.

2. Contact members of the Bar whom you know.

3. Call on government agencies which have, or may have, an interest in the area with which you are concerned. If your problem concerns land use, remember that many municipalities have a planner. Give him/her a call. The ministry of the environment may be able to answer your questions and give leads to where to get help.

4. Contact people whom you believe may be knowledgeable about the area with which you are concerned - planners, biologists, hydrologists, lawyers, your local M.P.P., etc.

5. Contact your local library or law library.

APPENDIX A: AN EXAMPLE OF RULES OF PROCEDURE
(promulgated by the Ontario Niagara Escarpment Commission for a hearing with respect to a proposed plan)

The following Rules of Procedure are established for the conduct of the hearing, pursuant to Section 10(5) of The Niagara Escarpment Planning and Development Act, 1973.

1. Representations made concerning The Proposed Plan for the Niagara Escarpment at the hearing may be made orally or in writing and will not be made under oath or affirmation.

2. Representations and documents submitted to the hearing officers may be received at their discretion provided they are relevant to the subject matter of the hearing.

3. Representations may be made in person, but if persons wish to retain counsel or agents to represent them, they may do so.

4. The initial stage of the hearing will be held at Marritt Hall, Ancaster Fair Grounds, Highway 53 at Southcote Road, Ancaster, Ontario, and will involve the presentation of The Proposed Plan for the Niagara Escarpment by the Niagara Escarpment Commission or its representatives. Questions may then be asked of the Commission's representatives dealing with issues concerning The Proposed Plan for the Niagara Escarpment as a whole, and following this, representations dealing with The Proposed Plan as a whole will be received from any person desiring to do so.

5. Following the procedure to be carried out in section 4 of these Rules of Procedure, and at the same location, representations dealing with the specific section of The Proposed Plan within the Regional Municipality of Hamilton-Wentworth will be received from any person desiring to do so.

6. There will also be a hearing near or in the City of Owen Sound at which time a presentation of The Proposed Plan for the Niagara Escarpment will be made by the Niagara Escarpment Commission or its representatives. Questions may then be asked of the Commission's representatives dealing with issues concerning The Proposed Plan for the Niagara Escarpment as a whole, and following this, representations dealing with The Proposed Plan as a whole will be received from any person desiring to do so.

7. Subsequent stages of the hearing will deal with issues in specific sections of the area covered by The Proposed Plan for the Niagara Escarpment and will be held at several locations in the planning area or in the general proximity thereof. Notice of dates, times and places will be published in advance. Notice will also be given to persons who have indicated their intention to make representations or submit questions concerning The Proposed Plan.

8. Members of the public or their representatives and representatives of the Niagara Escarpment Commission may question anyone appearing before the hearing officers on the whole or any part of the Plan.

9. The hearing officers may ask questions of any person appearing before them.

10. At appropriate times, those who presented The Proposed Plan may deliver a summary of their presentation at the discretion of the hearing officers.

11. Any two hearing officers appointed to this hearing may be considered a quorum for the purpose of hearing representations.

CHAPTER 6

ENVIRONMENTAL IMPACT ASSESSMENT FOR URBAN NATURAL AREAS

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6.1 INTRODUCTION

For several decades, citizen groups have been challenging developers at public hearings. Recently, the process has become more formalized with more and more jurisdictions requiring Environmental Impact Assessments (EIA's). But the task of challenging an EIA has seemed formidable. The EIA documents prepared by the project's proponent, usually a government agency or a professional consultant, have been highly technical and often the size of a small city telephone book. Citizens have been reluctant to criticize EIA's and strong challenges from opponents of projects have not been common.

The requirement for EIA's is growing across Canada. At the federal level, EIA's have been required since 1973 when the Cabinet established the Environmental Assessment and Review Process (EARP). Under EARP, federal departments, crown corporations, and private companies receiving federal funds are required to prepare an EIA for all projects which might have an adverse effect on the environment. At the provincial level, the use of EIA's will inevitably increase as the provinces continue to develop and expand their own EIA requirements. At this time, nine provinces have established EIA procedures, seven by using existing environmental legislation as a means to require an EIA, while New Brunswick has followed the federal example of establishing an EIA policy along with an administrative process to make sure EIA's are undertaken. Ontario is unique in being the only province to pass a new act (The Environmental Assessment Act, 1975) along the lines of the American model which requires that an EIA be prepared for a wide range of public and private projects before approval to proceed is given (Table 6-1).

Canadian experience in municipal environmental impact assessment processes is quite limited. The City of Winnipeg in 1972 adopted a legal requirement for impact studies of public projects, but this has been considerably scaled down as a result of legal challenges and internal problems. Several Ontario municipalities, the Regional Municipality of Waterloo and the City of Mississauga, for example, have also instituted EIA requirements. Recently, in 1980, Ontario implemented regulations requiring EIA's for municipal projects exceeding two million dollars in cost.[1] It is likely that similar requirements will eventually be imposed in other provinces as well.

The trend in Canada is, therefore, to increase the use of the impact assessment process. Consequently there is a need for individuals interested in environmental protection to understand what an EIA is, what its components are, and most important, what are its strengths and weaknesses.

The purpose of this chapter is not to guide the reader in preparing an EIA. The preparation of an EIA document usually involves a comprehensive and expensive study with several participating disciplines (ecology, economics, sociology) and often exceeds a year in preparation time. Guidelines for preparing an EIA are well documented elsewhere.[2]

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[1] Amendments to Ontario's Environmental Assessment Act were made in June and October, 1980. Those amendments required EIA's be prepared for all municipal projects which were likely to have a significant environmental impact: hazardous waste sites; new rail facilities; land fill sites serving a population larger than 1500 people; and others. EIA's were also required for other municipal projects exceeding a cost of two million dollars. The amendments also listed projects exempted from the municipal EIA requirement: drainage works; subdivision agreements; and others.

[2] For guides to the preparation of an EIA, the reader should consult one or more of the following references: Canter (1977); Dickert and Domeny (1974); Munn (1979). For additional references on preparing an EIA see Armour (1979).

Table 6-1. Provincial approaches to environmental impact assessment, 1980

Provinces	Basis for environmental assessment		
	Use specific act	Use other environmental legislation	Use EA policy or administrative procedure
British Columbia		x	xa
Alberta		x	
Saskatchewan		x	xb
Manitoba		x	xb
Ontario	x		
Quebec	xc	x	
New Brunswick			xa
Nova Scotia		x	
Newfoundland	xc	x	xb
Prince Edward Island			x

a = for public projects; b = underway; c = being considered
Adapted from Lang and Armour (1978)

British Columbia: The Environment and Land Use Act, 1971; Land Act, 1970; Pollution Control Act; Coal Mines Regulation Act, 1969; The Water Act, 1960; Guidelines for Environmental Impact Assessment of Power Projects; Coal Development Guidelines; Guidelines for Linear Developments; Guidelines for Environmental Impact; Control of Development on B.C. Crown Lands.

Alberta: The Land Surface and Reclamation Act, Chapter 34, 1973; Environmental Impact Assessment System Guidelines.

Saskatchewan: Department of the Environment Act, Chapter 31, 1972; Environmental Impact Assessment Policy and Guidelines.

Manitoba: Clean Environment Act, Chapter 130, 1972; Environmental Assessment and Review Policy.

Ontario: The Environmental Assessment Act, 1975; Environmental Assessment Guidelines.

Quebec: The Environmental Quality Act, Chapter 49, 1972; Regulations.

New Brunswick: Environmental Impact Assessment Policy, 1975.

Nova Scotia: The Environmental Protection Act, Chapter 6, 1973; The Water Act, Chapter 335, 1973; Guidelines for Environmental Assessment.

Prince Edward Island: Executive Council Minute 16/73, 1973.

Newfoundland: Approval in principle given to the drafting of an Environmental Assessment Act.

The environmental activist will most often be reviewing or challenging an EIA document done by others. Consequently, the purpose of this chapter is to explain the EIA process in simple terms and to examine the contents of a typical EIA document so that the activist or student can successfully review an existing EIA. It should be clear that the EIA process presents an important opportunity to seek to protect natural features in urban areas. As the EIA process becomes more widely used, those individuals most successful in preserving woodlots, ravine lands, wetlands and wildlife habitat in urban areas will be those who successfully challenge existing EIA's and who force the EIA process to give sufficient weight to natural amenities.

6.2 THE ORIGINS OF EIA

An EIA is a form of pre-action evaluation that was designed to determine whether or not to proceed with a project so as to prevent or minimize environmental degradation. The need for a decision-making mechanism like EIA arose from the bitter experience of having to live with the environmental consequences of large-scale public and private projects. In the prosperous years of the 1950's and 1960's, a large number of dams, highways, canals, airports and residential subdivisions were built at a rapid pace with little forethought given to potentially harmful environmental changes. Time after time, decision-makers were surprised to learn that unanticipated and undesirable environmental changes had occurred as a result of those projects. Unwanted changes were typically discovered after the project had been completed when little could be done to remedy the damage.

One was the W.A.C. Bennet Dam constructed on the Peace River in British Columbia in 1967. The dam was built to provide water storage and electric power for the province; however, it was discovered after the dam was completed, that holding back the river was depriving the Peace-Athabasca delta (1110 km downstream) of necessary water flows. The annual spring flood proved to be essential to the ecosystems of the delta. Continued withholding of flood water would have meant a permanent reduction in biological productivity. After discovering these impacts, modifications were made to the dam to allow some flood water to reach the delta; however, the modifications were costly and did not totally repair the damage done.

After a number of such unhappy experiences, environmental activists of the late 1960's and early 1970's persuaded legislators that some means were needed to discover the probable results of major projects before construction.[3] If environmental changes were known in advance, those projects causing minor environmental changes could be approved, while projects likely to cause major impacts could be rejected before funds had been committed or construction started. In some instances, projects likely to cause major impacts could be approved if it was possible to adopt measures to mitigate or repair adverse effects.

6.3 BASIC ELEMENTS OF AN EIA

At its simplest, an EIA is a decision-making document designed to indicate whether a proposed action should be allowed to proceed or not by the decision-maker. An EIA helps in shaping a decision by following three basic steps:

1. Description - describing the project, its alternatives and the environment to be affected.

2. Prediction - predicting the likely impacts of the project and its alternatives on the environment to be affected.

3. Evaluation - weighing the magnitude and significance of the expected adverse impacts against the beneficial impacts expected from the project.

If the expected benefits of the new project are likely to be more beneficial than the harm done to the environment, the EIA should recommend approval. If, on the other hand, the project is likely to cause extensive environmental damage while the expected benefits are small, the EIA should recommend rejection.

Description, prediction and evaluation are the three fundamental components of an EIA. Each impact assessment, regardless of size, technical sophistication or

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[3]The first EIA mechanism to meet this need was created in the National Environmental Policy Act of 1969 (NEPA) in the United States. There has been considerable experimentation in the 1970's with the format and content of EIA's in the United States and Canada as interested parties and legislators have sought to expand and improve the EIA mechanism. The formal requirements implemented in Canada at all three levels of government (federal, provincial and municipal) are briefly reviewed in the introduction (Section 6.1).

complexity must have each of these components to be complete, although the format and content may differ between documents with wide variation in methods used to predict impacts and to evaluate them. A detailed discussion of the description-prediction-evaluation structure of the EIA process follows.

DESCRIPTION

Each EIA must describe in the early part of the document both the project, a set of alternatives and the environment to be affected. First, it must identify the project (a dam, bridge or highway) and describe its location, physical dimensions and construction. Unlike general planning studies, an EIA attempts to estimate the probable changes resulting from a particular project. Therefore, the EIA should describe in adequate detail exactly what the proponent intends to do, where he intends to do it, and how he proposes to go about it.

If the project is a dam, the EIA should describe its location and capacity, as well as the level and spatial extent of the reservoir created by the dam. It should also describe the number of people to be employed constructing it, the time required to construct it, its capacity for recreation, the power it will generate, and other related details. In this way,a clear picture of precisely what will be done is provided for the reviewer.

Secondly, an EIA also requires the proponent to describe alternate ways of meeting the need for which the project has been proposed. There are many different ways of meeting the same goal. Knowing that the object of an EIA is to avoid the unexpected negative impacts of a project, it is only reasonable that an alternative should be chosen that meets the need while causing the least environmental damage.

Requirements for EIA in Canadian jurisdictions often specify that two types of alternatives be considered:

1. alternative ways of carrying out the project; and,

2. alternatives to the project.

If the example is a proposed highway between two towns (A and B), then there are alternative ways of carrying out the project using the approach the proponent has chosen (Fig. 6-1).

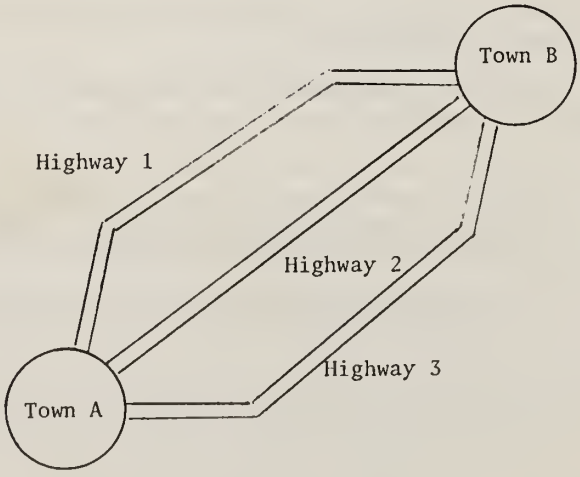

Fig. 6-1. Alternative ways of carrying out the project

Figure 6-1 indicates that there are three alternative routes for a highway between towns A and B. Routes 1, 2 and 3 are alternative ways of carrying out the project. The project type (a highway) remains unchanged.

There are also alternatives to the project that do not involve the original project type, but rather employ other methods besides the one favoured by the proponent to meet the need. Figure 6.2 indicates that there are three alternatives to the project; air service, a bus line and rail service.

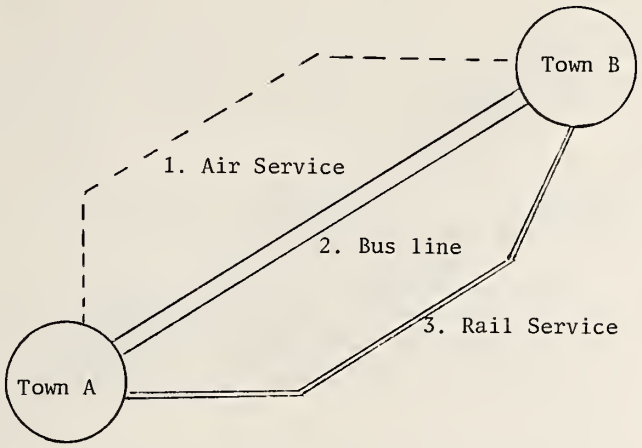

Fig. 6-2. Alternatives to the project

By requiring that both alternative types be included in an EIA, legislators have attempted to ensure that the broadest array of viable alternatives will be considered in an assessment.

Third, an EIA must identify and describe the environment to be affected by the project. The word "environment" is broadly defined in most legislation and regulations to include not only the natural environment but the social and economic environments as well. In the natural environment case, for example, the description should include the natural systems that will likely be affected, such as woodlots, stream channels and wetlands; their physical properties (soils, topography, climate and drainage); and the biotic communities living in these habitats (vegetation, terrestrial and aquatic species).[4]

The identification of the environment to be affected by the project is a critical element in an EIA study. Generally, the area that will be affected by the project is *much larger* than the physical extent of the project or its property boundaries. The W.A.C. Bennet dam is an extreme example where the affected environment extended hundreds of kilometers downstream. However, in most projects, there are some impacts which typically affect large areas. Noise from an airport will affect residents along the flight path several kilometers beyond the airport perimeter. Similarly, water contaminants from an industrial facility will affect water users a considerable distance downstream from the effluent pipe. The environment to be affected should be broad enough to include those impacts.

Project proponents, however, tend to consider the impact area in narrow terms. They are reluctant to consider environmental features some distance from their

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[4]The geophysical and biotic factors are dealt with in greater detail in Chapters 7 and 8 respectively. Socio-economic factors are discussed in Chapter 9. Reference should be made to these chapters for comprehensive discussion of the factors to be included in an EIA.

projects because the smaller the area to be considered, the smaller the number of impacts is likely to be. Instead, they prefer to define the impact area as close as possible to the boundary of the property obtained for the project.

An example is a proposed highway which will pass through a major woodlot (Fig. 6-3). The tendency of the proponent is to define the impact area using the right-of-way boundaries. However, since drainage features and wildlife movement in the woodlot would be substantially changed, the environment to be affected should include woodcover and drainage features.

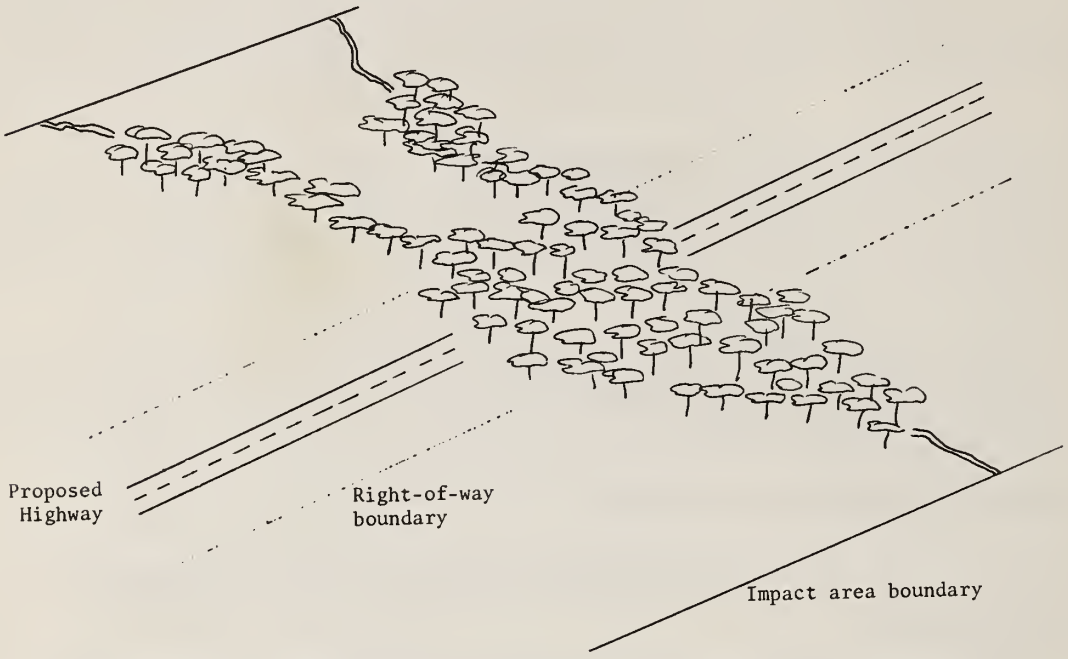

Fig. 6-3. Impact area for a woodlot

Although there are no clear guidelines for determining the boundaries of the environment to be affected, reviewers of an EIA can judge whether the size of the impact area or the array of impact features (soils, drainage, vegetation, wildlife, etc.) is reasonable given their knowledge of the area and its features. If the environment to be affected is defined narrowly, as in the above example, there is reason to challenge the results of the EIA for having omitted a significant area or feature in its assessment of project impacts.

PREDICTION

Once the project has been identified and the environment described, an EIA attempts to predict the impact of the project and its alternatives on the environment. The prediction of impacts lies at the heart of each EIA because the EIA's purpose is to make the environmental consequences of a project known to the decision-maker before the project is approved. This requires an estimate of the environmental changes that will take place.

Unfortunately, predicting the impacts of a physical change such as a dam or highway on complex natural systems (drainage systems, species reproduction and movement, water quality) is much easier said than done. Although there are a number of methods commonly used to predict impacts of projects in EIA studies, the predictions are often unreliable.

The low reliability of impact predictions is due to the complexity of natural systems and their dynamic behaviours. Natural systems tend to behave in unpredictable ways because they have many non-linear and random elements.[5] A change started in one part of a natural system may not move linearly to another part. Instead, it may affect unexpected parts of the natural system through indirect paths of cause and effect making the prediction of those effects extremely difficult.[6] Nevertheless, despite these limitations, each EIA is compelled to make predictions of the likely outcomes of a project. The result is that an EIA often contains questionable predictions of what will happen after the project has been built.

In many EIA studies in the past, impact prediction was simply a matter of judgement. Predictions were based on the intuition of the proponents; in other words, what the builder thought might happen if the project were built. In recent years, however, EIA preparers have attempted to move away from such subjective and unreliable techniques. The EIA studies have tended to be formal using a more systematic set of impact prediction methods.

Although there are several prediction methods available, the assessor conventionally relies on three kinds of impact prediction; engineering methods, expert opinion and comparative methods. These approaches can be described as follows:

1. Engineering methods - Engineering studies have established a number of cause and effect relationships between specific physical actions (the construction of a dam or a smoke stack) and resulting changes in water or air quality. Engineering methods can be used to estimate the changes likely caused by an action and often whether an air or water quality standard will be met.

2. Expert opinion - This method attempts to collect the opinion of experts on the likely outcomes of a project. Experts are usually assembled as a team and are asked to estimate probable changes within their areas of expertise.

3. Comparative methods (checklists) - The impact assessor can estimate the changes likely to occur in his project by referring to a comprehensive list of changes that have been associated with specific project types. The assessor selects (checks) those changes likely to occur. Such checklists can be found for most conventional projects.[7]

In Table 6-2 a checklist of possible changes is presented for a transportation project organized by phase of project development.

Frequently, checklists are presented in a matrix form to indicate cause-effect relationships. This is done by placing two checklists on the axis of a simple two-dimension matrix. One list is the set of actions required for a project and the other is a list of environmental characteristics that might be affected. Each cell in the matrix indicates a possible change in one environmental characteristic caused by one specific action. Figure 6-4 provides a partial illustration of the Leopold *et al.* (1971) impact matrix.

Although the prediction of impacts is a central element of an EIA, the methods most frequently used to predict impacts are not often reliable, consequently

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[5]A linear function is a constant increasing or decreasing trend as, for example, in linear growth. Non-linear growth, on the other hand, is characterized by variable growth rates over time. These variations may or may not be regular.

[6]For a discussion of the difficulties in predicting the outcomes of physical changes in complex natural systems, see Holling (1978).

[7]Canter (1977), Holling (1978) and Munn (1979) provide general discussions of procedures and methods used for prediction in the EIA process. Armour (1979), refers to several key references which discuss the comparative methods used for predicting the impacts associated with seven specific project types - highways; airports; railways and rail transit systems; sewage and solid waste; water resources; energy development, transmission and use; and new towns and subdivisions - in her recent annotated bibliography of EIA literature.

Table 6-2. List of potential impacts for a transportation project organized by phase of project development

I. PLANNING AND DESIGN PHASE

- A. Impact on land use through speculation in anticipation of development
- B. Impact of uncertainty on economic and social attributes of nearby areas
- C. Impact on other planning and provision of public services
- D. Acquisition and condemnation of property for project, with subsequent dislocation of families and businesses

II. CONSTRUCTION PHASE

- A. Displacement of people
- B. Noise
- C. Soil erosion and disturbance of natural drainage
- D. Interference with water table
- E. Water pollution
- F. Air pollution (including dust, dirt and burning of debris)
- G. Destruction of or damage to wildlife habitat
- H. Destruction of parks, recreation areas, historical sites
- I. Aesthetic impact of construction activity and destruction of or interference with scenic areas
- J. Impact of ancillary activities (e.g. disposal of earth, acquisition of gravel and fill)
- K. Commitment of resources to construction
- L. Safety hazards

III. OPERATION OF FACILITY

- A. Direct
  1. Noise
  2. Air pollution
  3. Water pollution
  4. Socio-economic
  5. Aesthetic
  6. Effects on animal and plant life (ecology)
  7. Demands for energy resources
- B. Indirect
  1. Contiguous land use
  2. Regional development patterns
  3. Demand for housing and public facilities
  4. Impact on use of nearby environmental amenities (e.g. parks, woodlands, recreation areas)
  5. Impact of additional and/or improved transportation into congested areas on those areas
  6. Differential usefulness for different economic and ethnic groups (and resulting problems and solutions)
  7. Impact on life styles of increased mobility and other impacts
  8. Impact of improved facility on transportation and related technological development (and consequent impacts)

Source: Canter (1977)

INSTRUCTIONS

1- Identify all actions (located across the top of the matrix) that are part of the proposed project.
2- Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible.
3- Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greatest magnitude of impact and 1, the least, (no zeroes). Before each number place + if the impact would be beneficial. In the lower right-hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e. g. regional vs. local); 10 represents the greatest importance and 1, the least (no zeroes).
4- The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with the larger numbers.

SAMPLE MATRIX

	a	b	c	d	e
a		2/1			8/2
b		7/2	8/8	3/1	9/7

	A MODIFICATION OF REGIME	B LAND TRANSFORMATION AND CONSTRUCTION
a	Exotic flora or fauna introduction	Urbanization
b	Biological controls	Industrial sites and buildings
c	Modification of habitat	Airports
d	Alteration of ground cover	Highways and bridges
e	Alteration of ground water hydrology	Roads and trails
f	Alteration of drainage	Railroads
g	River control and flow modification	Cables and lifts
h	Canalization	Transmission lines, pipelines and corridors
i	Irrigation	Barriers including fencing
j	Weather modification	Channel dredging and straightening
k	Burning	Channel revetments
l	Surface or paving	Canals
m	Noise and vibration	Dams and impoundments
n		Piers, seawalls, marinas, and sea terminals
o		Offshore structures
p		Recreational structures
q		Blasting and drilling
r		Cut and fill
s		Tunnels and underground structures

A PHYSICAL AND CHEMICAL CHARACTERISTICS		PROPOSED ACTIONS
1 EARTH	a	Mineral resources
	b	Construction material
	c	Soils
	d	Land form
	e	Force fields and background radiation
	f	Unique physical features
2 WATER	a	Surface
	b	Ocean
	c	Underground
	d	Quality
	e	Temperature
	f	Recharge
	g	Snow, ice, and permafrost
3 ATMOSPHERE	a	Quality (gases, particulates)
	b	Climate (micro, macro)
	c.	Temperature
4 PROCESSES	a	Floods
	b	Erosion
	c	Deposition (sedimentation, precipitation)
	d	Solution
	e	Sorption (ion exchange, complexing)
	f	Compaction and settling
	g	Stability (slides, slumps)
	h.	Stress-strain (earthquake)
	i	Air movements

Fig. 6-4. Impact matrix (Source: Leopold *et al.* 1971)

predictions based on the judgement of experts or derived from a simple two-dimensional matrix inspire a low level of confidence. The prediction element of an EIA should be, therefore, an important focus of attention for an EIA reviewer.

EVALUATION

In the prediction stage, a large number of expected geophysical, biotic, social and economic impacts are generated for the project and each alternative. The wide range of impacts predicted presents a complex picture of desirable and undesirable changes for the decision-maker and there is often no alternative that is obviously the best choice. The problem is to choose the right alternative.

The EIA must identify that alternative which satisfies the goals of the project while avoiding an unacceptable level of environmental damage. The EIA may also suggest project modifications to further mitigate or repair expected environmental damage. Therefore, the evaluation task is to select that alternative which has the best balance of positive and negative impacts. This selection can be done *informally* by the decision-maker through visual inspection of the impacts or *formally* by a systematic method that calculates a total score based on individual impacts.

Informal evaluation has been common practice in public decisions before impact assessment. However, informal decisions are largely influenced by the personal opinions and preferences of the decision-maker. He may choose to approve an action he prefers even though its impacts are significant. Also, informal approaches are not easily able to deal with complex evaluation problems. If, for example, a project has a set of six alternatives with ten impacts for each alternative, the decision-maker would have to visually examine sixty impacts at once to choose the appropriate alternative. This may be impossible to do with any degree of fairness and consequently may not lead to the choice of the most appropriate alternative.

Evaluation methods used in an EIA are usually formal procedures which systematically combine the values of each impact into a single value to make the choice among alternatives easier. This process occurs in two phases: analysis, in which the project is divided into action segments and the impacts of each individual action are predicted, and synthesis, in which the impacts for each individual action are aggregated into a single judgement (Fig. 6-5).

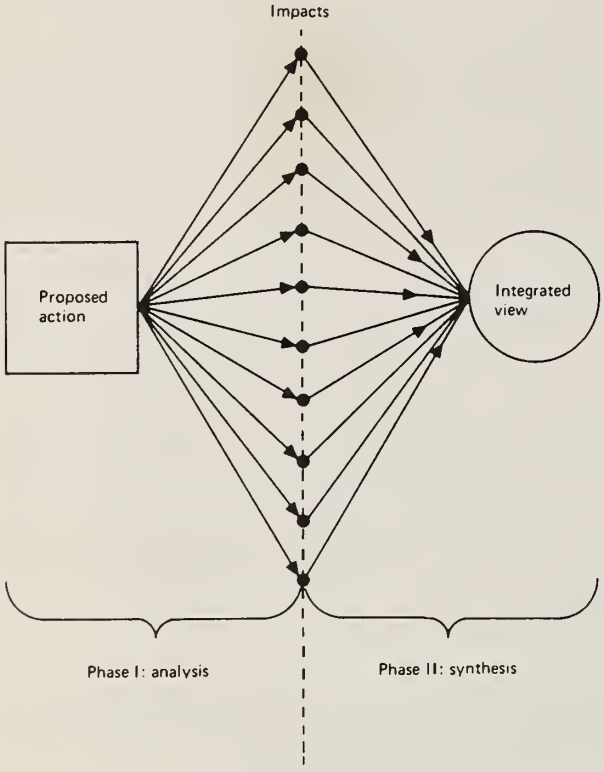

Fig. 6-5. The two phases of evaluation
Source: McAllister (1980)

In addition, formal evaluations in an EIA usually include an objectively derived weighting factor which indicates how the welfare of society as a whole would be affected by project impacts. The weighting factor is used to avoid the previously common practice of the decision-maker approving his favourite project although it reduced overall environmental quality. With a weighting factor, each project impact is weighted and a total score based on each impact is calculated. Formal evaluations in an EIA attempt to select the alternative that will avoid serious environmental impacts. These methods *encourage* decision-makers to approve those projects that improve general environmental quality rather than those which improve the decision-maker's welfare. The EIA's *do not require* decision-makers to approve the former over the latter in most Canadian jurisdictions, as the adoption of the recommendations of an EIA are usually discretionary, and not mandatory.

The two common methods of evaluation used in EIA's that are systematic and objective are environmental quality indices and cost-benefit analysis. These two methods are discussed in turn.

1. Environmental quality indices

This common method of evaluating alternatives in an EIA relies on the assignment of a number score which indicates the severity of the impact multiplied by a weighting value indicating the importance of that impact to arrive at an index of environmental quality. This procedure is illustrated in Fig. 6-6.

Impact parameter	SCORE	x	WEIGHT	=	Environmental quality index
	severity of impact		importance of impact		

Fig. 6-6. Environmental quality index computations

The best alternative is one which attains the highest environmental quality index number summed for all individual impacts. This is known as the Batelle method, first devised for evaluating water development projects, and now used for evaluating a wide range of environmental impacts associated with different types of projects.[8]

2. Cost-benefit analysis

Cost-benefit analysis (CBA) is a method of choosing an alternative by assigning each impact a dollar value. Positive and negative impacts are termed benefits and costs, and are assigned positive and negative dollar values respectively. To make the correct choice, the dollar costs and dollar benefits for each alternative are added up over the expected life of the project. The most appropriate alternative is the one for which the benefits total exceeds the costs total by the greatest margin and/or the alternative which has the largest benefit-cost ratio. This method is dealt with in more detail in Chapter 9.

While a detailed discussion of these and other evaluation methods is beyond the scope of this chapter,[9] it is important that the reviewer be aware of some of the difficulties with most evaluation approaches. Frequently, a large number of impact values are synthesized to produce a single value for each alternative. In this way, a number of alternatives can be compared in one dimension to make the crucial choice. However, there are major problems that affect the outcomes of evaluation that are not resolved by most evaluation methods. These are:

(a) The selection of impact parameters can be substantially biased because there are no firm guides for selecting them. The number and choice of parameters can significantly alter the evaluation outcome.

(b) There are immeasurable and intangible impacts that may be overlooked because they do not have a dollar value or are not easily assigned a score. Such items as scenic vistas, close family ties in a community, or the presence of rare species of plants are not easily quantified and may be neglected.

(c) There is an enormous problem in dealing with the timing of impacts. Some impacts occur immediately while others take many years to occur. Evaluation methods are limited in their ability to deal with differences between short-term and long-term impacts.

(d) There is a major problem in dealing with the distribution of impacts. While the total number of impacts of the best alternative may be small, those impacts may all be felt by some small group in society. In most EIA's the distribution of impacts tends to be ignored, consequently the evaluation methods used do not distribute impacts equitably.

This discussion illustrates some of the problems associated with EIA evaluations. The important point for the EIA reviewer is the fact that, despite

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[8]The original method proposed by Dee *et al.* (1973) has been converted and applied to a rapid transit system project in Atlanta (Smith 1974), and to residential subdivision development projects in Oakville, Ontario (Paterson and Dillon 1974). A copy of the latter can be found in the Municipal Reference section of the Metropolitan Toronto Library system.

[9]For a comprehensive review of evaluation methods see McAllister (1980).

attempts to be systematic and objective, evaluation methods presently used to make decisions on large public projects are open to bias. Each EIA evaluation should be scrutinized carefully by the EIA reviewer. In particular, the steps taken to include all relevant impact categories, to objectively develop a social weighting scheme, and to systematically calculate the final score should be closely examined.

6.4 AN EXAMPLE OF AN EIA DOCUMENT

TABLE OF CONTENTS

A reviewer opening the cover of an EIA document prepared for a sewer project in Ontario would likely find the following:

1. Description of the proposed sewer
2. Need for the sewer
3. Existing environmental conditions - the baseline study
4. The alternative to the project
   (a) the "do nothing" alternative
   (b) alternatives to the project
5. Prediction of impacts
   (a) IRREVERSIBLE impacts
   (b) adverse impacts that CANNOT be avoided
6. Evaluation of alternatives
7. Selection
8. Remedial and mitigating measures
9. The recommended alternative

Obviously many of the items in this table of contents are additions to the description-prediction-evaluation format described in Section 6.3, and it is useful to examine some of the unfamiliar items to see where they fit within the basic EIA model.

UNFAMILIAR ITEMS IN THE TABLE OF CONTENTS

A. *NEED* FOR THE SEWER

Most EIA legislation in Canada requires the proponent to present an argument explaining why the project is needed, that is, *why* he is doing it.[10] If the project was being developed by a private business, the explanation would likely be to obtain a reasonable return on investment. But, since most projects requiring an EIA are government actions, the typical need arguments are based on diminishing capacity of a public service system, such as a sewer, and a projected increase in demand. The agency responsible for providing sewer services may argue that the capacity of the existing sewer system is fixed and the projected demand for sewer services in a particular location is increasing. Thus, the project is needed if expected demands for sewer services are to be met.

Need statements are required in many EIA's because identifying the need is important in guiding the choice of alternatives. If the need is expanding sewage disposal capacity, the alternatives may indicate ways of doing so without building a sewer (small sewage disposal mechanisms in each house, land disposal of sewage, or other alternatives). Need statements are also useful as a preliminary means of evaluating the project. If the need is not pressing and the cost of the project is high, then the project may be rejected on the basis of low need because the resources required for the project could be spent more effectively elsewhere.

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[10] Section 5(3)(6) of the Ontario Environmental Assessment Act, for example, calls for a statement of the rationale for: (a) the undertaking; (b) the alternative methods of carrying out the undertaking; and, (c) the alternatives to the undertaking.

B. EXISTING ENVIRONMENTAL CONDITIONS - THE *BASELINE* STUDY

The *baseline* study or existing environmental conditions are other names for the description of the environment to be affected. Baseline studies usually occupy the largest portion of the document and are typically the most technical and confusing parts of the study. While the purpose is to describe the relevant environment in order to judge the degree of impact, the baseline usually contains a comprehensive listing of all important and unimportant impact categories along with a detailed description of each feature.

For example, the baseline segment of an EIA for a sewer project might include the following impact categories:

- climate
- physiography
- geology
- drainage
- soils
- air quality
- water quality
- vegetation
- terrestrial species
- aquatic species
- avian species
- social cohesion
- neighbourhood vitality
- economic viability
- aesthetic features

One would also find some of the above categories broken down into minute components; for example:

Aquatic species
- vertebrates
- invertebrates
  - benthic
  - littoral
- microorganisms

Climate
- temperature
- precipitation
- wind velocity and direction
- sunlight
- extreme climatic events

The result is an extremely long list of impact categories each containing extensive detail on the number of species present, their concentration, movement, habitat, etc.

It is a common refrain in the EIA literature that little of this information ever plays a role in the actual decision to approve or reject the project. Often for a sewer project, the climatic detail (listed above) is irrelevant to the decision. In other cases, the level of detail is of no consequence since values for a specific category remain unchanged for all the alternatives, that is, there is no impact. An example of this is the lack of impact of a bridge on stream microorganisms once construction is completed.

In the sewer case, the inclusion of overwhelming detail in the baseline segment does not aid in the decision, rather it fattens the EIA document, increases its complexity, and makes it more difficult for the reviewer to interpret.[11] It is important to recall that the baseline portion of an EIA is nothing more than a description of the environment that will be affected, and that in all likelihood, the level of detail is far in excess of what is necessary to make the decision. The EIA reviewer should learn to review this section in a cursory fashion and devote most attention to the prediction and evaluation portions of the study referring back to the baseline where necessary.

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[11] The problem of cumbersome detail in baseline studies has reached such proportions that attempts are being made in the United States to "scope" the extent of EIA studies. A scoping process was incorporated in the United States Federal EIA procedures in November 1978, to determine the proper content of an EIA before it is prepared. Scoping has been designed to avoid subsequent criticism at two extremes: that unnecessary matters were included, and that essential matters were overlooked in EIA's.

C. THE *DO-NOTHING* ALTERNATIVE

The basic purpose of an impact assessment is to make decisions that avoid unexpected and unwanted environmental changes. One way to avoid such changes is to do nothing at all. In the United States, consideration of a "do-nothing" alternative has been legislated as a formal requirement of an EIA study. While this is not formally required in many Canadian procedures, consideration of this alternative is commonly included in Canadian EIA's.

The "do-nothing" alternative gives the decision-maker an opportunity to consider the need of the project. If, in comparison with other alternatives, the "do-nothing" alternative results in the least environmental damage while social and economic activities are not significantly affected, then the project can be rejected. This alternative is of great importance to the reviewer because the "do-nothing" option, if adequately considered, is a useful way of separating projects that are done for political and financial reasons from those that are actually needed. For example, if an EIA had been required for the Darlington nuclear facility in Ontario, an analysis of the "do-nothing" alternative would likely have indicated that the existing capacity for production of electrical power in the province substantially exceeded demand, consequently doing-nothing would have been the preferred alternative.[12]

D. IRREVERSIBLE AND UNAVOIDABLE IMPACTS

In the impact prediction segment of an EIA, impacts are often divided into two or more types: irreversible impacts and unavoidable impacts.

Irreversible impacts are those changes to the natural environment, the economy, or the community which are permanent. The most common examples are the extinction of a species or the introduction of a foreign species to an existing ecosystem. One example is the Garrison diversion project in North Dakota that Canada has opposed on the grounds that the diversion would introduce foreign fish species to Lake Winnipeg and irreversibly affect the commercially important white-fish population. Irreversible impacts are given particular attention in many EIA's because they are considered to be more serious than other impacts due to their permanence.

Unavoidable impacts are changes to the environment that cannot be prevented by changes in design of the project or location. The classic example of an unavoidable impact is the anticipated decrease in air quality that must occur as a result of building a new highway. Design changes may alter the speed at which cars travel while route location alternatives may avoid woodlots or water bodies. However, since all routes and all designs will generate automobile traffic, air quality must decrease due to added automobile emissions.

Like irreversible impacts, unavoidable impacts are given special attention in EIA documents because they are considered more important. The United States legislation requires that unavoidable impacts and irreversible commitments of resources both be included in an EIA. Irreversible and unavoidable impacts are often given similar treatment in EIA's in Canadian jurisdictions. However, this requirement is not usually mandatory so that such treatment is sometimes omitted.

The EIA reviewer should recognize that such categories of impact are merely attention-getting devices to draw the decision-maker's attention to specific impact types considered by legislators to be particularly important. There are no separate methods available to predict these impacts. Instead, they are predicted by conventional means, then separated from the other impact predictions to increase their visibility. Presumably the decision-maker will give such impacts additional consideration in making the final decision.

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[12] An EIA was not done for the Darlington nuclear facility because it was exempted from the requirements of the Ontario Environmental Assessment Act by Ontario's Minister of the Environment.

E. REMEDIAL AND MITIGATING MEASURES

Some EIA requirements demand that the document outline remedial and mitigating measures for various predicted impacts that are not avoidable.[13]

Mitigating measures are steps the proponent of a project can take during construction to lessen the impact of the project as described in the initial segment of the EIA. A sewer project which requires excavation through a stream bed can be scheduled to commence in the late summer or fall to reduce (mitigate) the impact on the spawning of aquatic species which typically takes place in the spring. Similarly, a highway project which requires a road cut through elevated topography can reduce erosion by sodding and staking of the road cuts during construction.

Remedial measures, on the other hand, are actions taken after the project is completed, to repair some of the unwanted impacts. Landscaping and tree planting may be used after the completion of a highway to repair the visual impacts of the new facility. Similarly, restocking of fish in a stream depleted by excess sedimentation from construction can restore original species numbers.

Remedial and mitigating measures are considered in an EIA because even those alternatives which have high evaluation scores often will generate significant environmental damage, and it is easier politically to approve a project when it is known that some of the negative effects can be repaired. While remedial and mitigating measures can make a difficult EIA decision more palatable, it is rare that such measures are able to change the evaluation outcome, instead they most often are used as cosmetic measures.

6.5 HOW TO REVIEW AN ENVIRONMENTAL IMPACT ASSESSMENT

Since it is increasingly likely that individuals interested in protecting environmental amenities will have to review and possibly challenge an existing Impact Assessment document, this chapter concludes with a discussion of the appropriate points of attention which should be considered by an EIA reviewer.[14]

THE ENVIRONMENT TO BE AFFECTED

It was pointed out earlier that it is in the proponent's interest to limit as much as possible, the area, and the set of impact categories that he must consider in an EIA. The smaller that area or set of impact categories, the fewer the number of impacts the proponent will have to deal with. Each developer wishes to convey in his EIA that the project will cause only modest, spatially limited environmental dangers. However, the experience has been that ecological, social and economic impacts have frequently been much more extensive than expected. Consequently, an important part of an EIA review is an examination of the environment to be affected. If the EIA has defined the environment too narrowly, it can be challenged by raising examples of similar projects that have had broader environmental consequences than those included in the document. One recent example was the successful challenge of an EIA for a proposed uranium refinery project near Warman, Saskatchewan. The Environmental Assessment Panel found in August 1980 that the proponent had defined the environment too narrowly by omitting religious affiliation and beliefs in its consideration of the social environment.

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[13] The Ontario legislation requires that the EIA describe actions that are necessary "to prevent, change, mitigate, or remedy the effects upon ... the environment". Section 5(3)(c)(iii).

[14] Often challenges to an EIA must be presented before an Environmental Assessment Board or a similar judicial body. In such cases, the formal rules of evidence and courtroom behaviour are often used. For ways of dealing with the hearing process in challenging an EIA, see Emond (1978); Emond and Roman (1980) and Roman *et al.* (1980). Emond discusses strategies for dealing with judicial proceedings in considerable detail.

THE CHOICE OF ALTERNATIVES

The part of an EIA document usually most open to criticism is the set of alternatives put forward by the proponent for evaluation. The proponent usually resents this aspect of the EIA process most, and rarely does it with much enthusiasm. The proponent is usually skilled at doing one thing very well; constructing highways, building subdivisions, laying sewer pipes, etc. Yet for an EIA, he is compelled to think of other ways of meeting the need or achieving the goal besides the "best" way, which is the way he intended doing it in the first place. The proponent often eliminates alternatives before the EIA is started, consequently, in most EIA's the choice of alternatives to be considered is usually very limited and narrow.

The requirements in most provinces in Canada call for EIA's to consider alternatives to the project as well as alternative ways of carrying out the project. Proposing agencies are required to make a good faith effort to consider to the fullest extent possible those alternatives that are "reasonably available". While this does not mean a developer has to consider alternatives that are remote (unproven technologies or unusual designs) it does mean that alternatives to the project should be viable and substantially different than different routes for a proposed highway, for example.

The alternative segment is, therefore, an important focus for the reviewer's attention. The reviewer should first call attention to the "do nothing" alternative, if the EIA in question has not included it. If, in evaluating the "do nothing" alternative, the proponent cannot argue that an important societal goal is not being met, then the project may be successfully challenged on the grounds that it is not needed. In addition to the "do nothing" alternative, the review group should attempt to identify other reasonable alternatives, which have not been included in the EIA that are lower in economic, environmental, or social costs.

A good example of the importance of the choice of alternatives is found in the Highway 24 Feasibility Study done for the Ministry of Transportation and Communications (MTC) of Ontario in 1975. The purpose of that project was to link the two cities of Cambridge and Guelph with a high-speed, inter-urban expressway. While the MTC favoured a new highway, local residents insisted that the upgrading of a portion of the existing highway be considered as an alternative. When that alternative was reluctantly considered, it was found to cost considerably less than a new facility and it produced significantly smaller impacts on the natural environment and on the local agricultural community. Thus, the EIA reviewer has considerable opportunity to protect environmental amenities by making sure that the widest range of alternatives has been included in the study.

PREDICTION

Predicted impacts for alternatives in an EIA are frequently presented in the document with some confidence. The reviewer often has the impression that predicted impacts are the result of an accurate, technical prediction process. However, as was discussed in Section 6.3, existing methods are limited in their predictive abilities; the impacts described are therefore probabilities, not certainties. They may occur, they may be more severe than predicted, or they may not occur at all.

The EIA reviewers should therefore question the confidence with which the predictions have been made. For example, an EIA done for a sewer project may predict a decrease in the local deer population of 100 animals, due to removal of woodcover habitat. If an examination of the prediction reveals that it has been made with an 80% level of confidence, the possible outcomes would range from 80 to 120 animals. This is illustrated in Fig. 6-7.

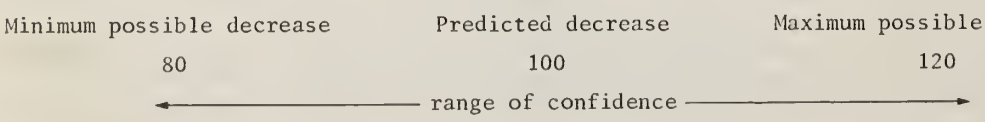

Fig. 6-7. Predictions made with an 80% level of confidence

By questioning the confidence of predictions, the reviewer may be able to establish that the maximum environmental impact (loss of 120 deer) is significant for that deer population. Thus, the project may not be worth the environmental risk given the confidence with which predictions have been made.

EVALUATION

The final focus of the reviewer's attention is the method of evaluating alternatives. The principal failing of most evaluation methods is that they are not objective. Although it is widely recognized that all environmental factors are not equally important, and that each must be weighted in the evaluation process in proportion to its importance, the method of weighting impacts must reflect the preferences of the community rather than the proponent. An evaluation method is objective if the impact categories chosen are appropriate to the environment likely to be affected. It is also objective if the weights assigned to each impact category are obtained from the community and are not created by the proponent.

The reviewer of an EIA can have considerable influence on an EIA decision by examining the evaluation method for the steps taken to objectively determine community preferences for the environmental factors being studied. If the weights used have not been fairly determined or if they do not adequately reflect community preferences, then an EIA may be open to challenge.

6.6 CONCLUSION

The impact assessment process in Canada has not been particularly effective in preventing actions and projects with undesirable environmental consequences from being taken or built. To this point, EIA's have generally tended to confirm the plans of project proponents. This has been due partly to the fact that impact assessments have only been required and produced consistently within the last five years in Canada. Consequently, the process is still relatively new to the decision-maker and to the citizen. While it is true that early EIA studies were poorly done with little attention paid to prediction methods or to the need for objectivity, a large portion of the ineffectiveness of early efforts was due to the general absence of a critical reviewing public.

Fortunately, that disinclination to review EIA documents is fast disappearing as members of the involved public come to understand the description-prediction-evaluation structure of an EIA and those aspects of the impact assessment process open to review:

- identification of the environment to be affected
- the choice of alternatives
- the confidence of impact predictions
- the objectivity in evaluation methods

As the impact assessment process becomes a part of standard practice for projects at the municipal level in Canada, environmental protection will depend on challenging projects which threaten natural areas by critically reviewing their Environmental Impact Assessments.

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CHAPTER 7

SUBSYSTEM STUDIES: GEOPHYSICAL FACTORS

This chapter discusses three geophysical factors that influence urban natural systems. The factors are climate, soils and hydrology.

7.1 CLIMATIC FACTORS

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7.1.1 THE THREE SCALES OF CLIMATE

A feature of Canadian climate is its variability from day to day and from place to place. One convenient way of interpreting this variability is according to the dimensions of the atmospheric processes which altogether determine local climate:

1. large-scale (macroscale) processes related to latitude, height above sea-level, and distance from oceans. (This is the scale of motion provided by surface weather maps, which reveal a never-ending succession of high and low pressure areas, and of warm and cold fronts);

2. medium-scale (mesoscale) processes related to terrain features like valleys and coastlines, which produce organized atmospheric phenomena like land and sea breezes, slope winds and urban heat islands;

3. small-scale (microscale) processes associated with trees, buildings, and other local obstructions to sunlight and wind.

In all three cases, the time of year must be considered when studying climate; for example, the sun's radiation is stronger in the summer than in the winter, and the land-lake temperature difference is reversed. For mesoscale and microscale processes, the time of day is also important; solar heating in the daytime is replaced by radiational cooling at night, for example.

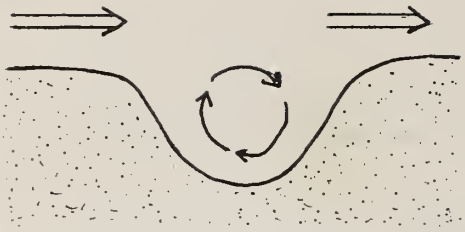
The emphasis here is on the mesoscale, which typically has the same dimensions as does a large city. However, the three scales interact in various ways, for example, mesoscale lake breezes are strongest when skies are clear and macroscale winds are weak.

Synoptic weather stations situated 300 to 500 km apart are used to follow the motions of macroscale systems, at 1, 3 or 6 hourly intervals. Some information on mesoscale processes can be inferred from networks of climatological stations operated by voluntary observers and reporting once daily maximum and minimum temperatures and precipitation.

7.1.2 MESOSCALE CLIMATE ON DAYS WHEN MACROSCALE WINDS ARE STRONG

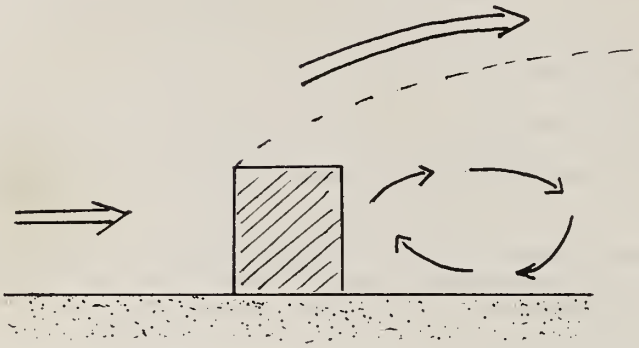
Strong winds mix the air and smooth away temperature and humidity differences. The mesoscale climate is then rather featureless. However, strong winds cause a number of aerodynamic effects. In all three cases illustrated in Fig. 7-1, the wind field is distorted and separate rotors or vortices are formed. The conditions depicted are average ones over an hour or so: from moment to moment, the wind tends to be gusty, with vortices forming and collapsing.

For each geometrical pattern, there is a critical wind speed above which the separation process occurs. Scale models can be placed in wind tunnels to determine this critical speed. In the outdoors, however, the wind direction varies from moment to moment, and it is difficult to predict the separation phenomenon in



(a) Valley cross-wind rotor

(b) Escarpment rotor



(c) Flow separation behind an obstacle

Fig. 7-1. Examples of aerodynamic effects during strong winds

advance, although easy to explain wind anomalies in retrospect. For example, extensive damage to trees may occur on only one side of a valley during a gale, due to aerodynamic effects.

These vortices exist also on the microscale downwind of single houses and trees. At a windy street corner such as Bloor and University in Toronto or Portage and Main in Winnipeg, the turbulent gusts and reversals in wind direction on opposite sides of the street can be easily observed. Similarly, flags on the tops of adjacent buildings may sometimes be seen to be pointing in different directions on a windy day.

Chimney effluents can sometimes be caught in these rotors and can be brought down to the ground in relatively high concentrations. Two examples are given in Fig. 7-2. Chimney pollution may sometimes enter a building through an open window but nearly always on the downwind side.

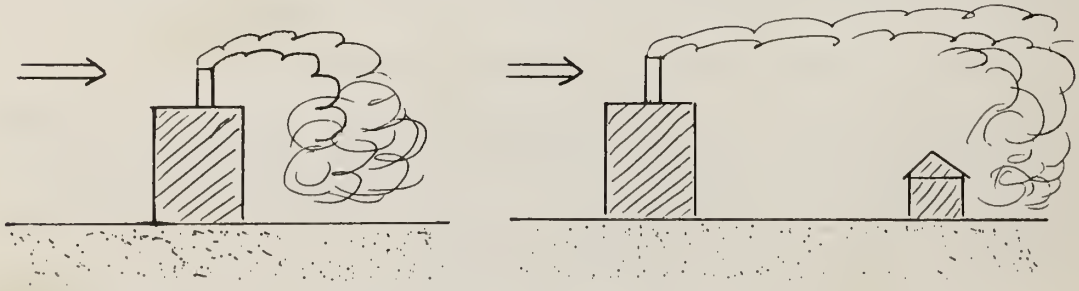


Fig. 7-2. Examples of aerodynamic downwash of chimney effluents

7.1.3 MESOSCALE CLIMATE ON DAYS WHEN MACROSCALE WINDS ARE LIGHT AND SKIES ARE CLEAR

When the macroscale wind field is weak and skies are clear (typically in a large atmospheric high pressure area), the temperature can vary by as much as 15 to 20 degrees from place to place due to differences in the nature of the underlying surface (forests *versus* farms; land *versus* water; city *versus* country; sunny slopes *versus* shady slopes). These temperature differences set the air in motion, at first as a gentle drift but later as a well-organized mesoscale wind field. A characteristic of many of these patterns is the day-night reversal in temperature differences and in the direction of air flow.

The main mesoscale wind fields are as follows:

LAKE AND LAND BREEZES. In summer during the daytime, a lake breeze develops as shown schematically in Fig. 7-3. For the first several hours, the wind blows at right angles to the coastline but, by late afternoon, the wind usually veers to a direction almost parallel to the shore. If the airmass is sufficiently moist, isolated thunderstorms may occur along the forward edge of the lake breeze (along the lake-breeze front). The dimensions of the wind circulation depend on air-water temperature differences, the curvature of the coastline, macroscale weather conditions and other factors. Occasionally, the inland penetration may be as much as 100 km.

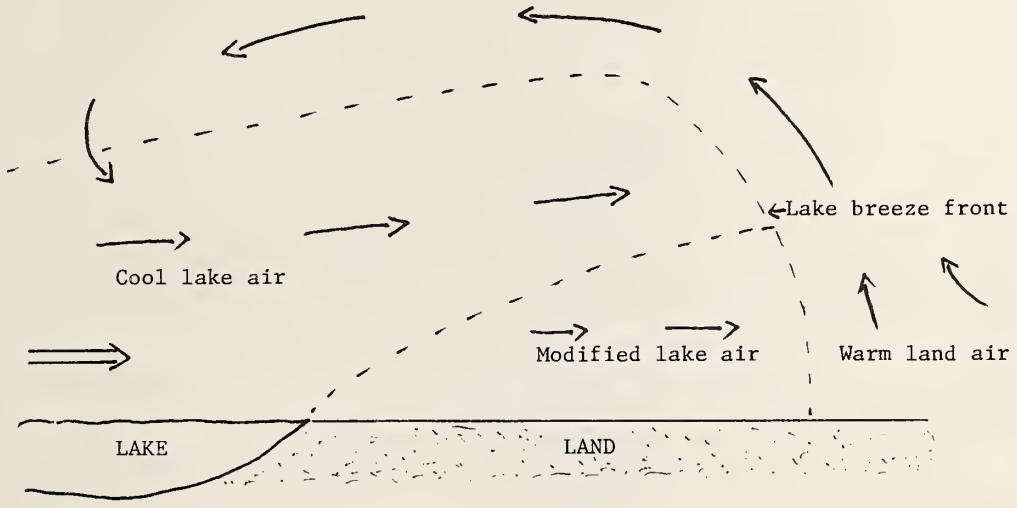


Fig. 7-3. A lake breeze

Near sunset the lake breeze fades away, often to be replaced by a night-time land breeze. However, the land breeze is weak and intermittent in character.

In winter, the land is colder than the water. Weak land breezes may then occur even during daylight hours.

SLOPE WINDS AND VALLEY FLOWS. Where land slopes consistently over a few kilometres, upslope winds occur in the daytime and downslope winds at night.

For valleys and ravines, the mesoscale wind circulations depend on the dimensions of the valley and on the orientation. For a valley aligned in the north-south direction, the western slope is heated in the morning, and the eastern slope in the afternoon. The resulting daytime wind fields are shown in Figs. 7-4(a) and 7-4(b). For a valley oriented in the east-west direction, the north-facing slope is in sunlight both morning and afternoon, so that there is only a single daytime circulation.

At night, the air drains down slopes and down valleys, as illustrated in Fig. 7-4(c). These flows are weaker and more erratic than the daytime upslope winds. The downvalley direction for cold air drainage is not necessarily the same as for river flow, but depends on whether the valley widens or narrows.

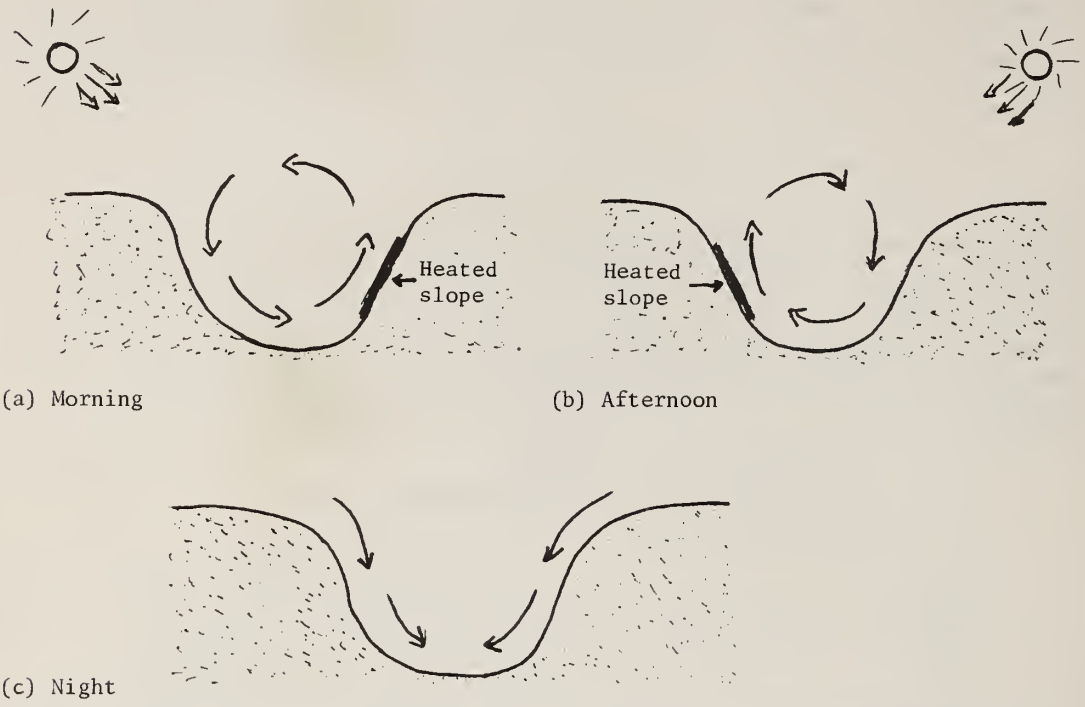


Fig. 7-4. Examples of slope and valley winds. In addition to the wind cells illustrated in the figure, the air is moving up the valley in (a) and (b) and down the valley in (c)

URBAN WIND CELLS. The *urban heat island* is an easily identifiable phenomenon in cities. The example shown in Fig. 7-5 is typical.

The heat island leads to a mesoscale wind field as shown in Fig. 7-6, in which there is a slow surface drift of air towards the centre of the city from all sides.

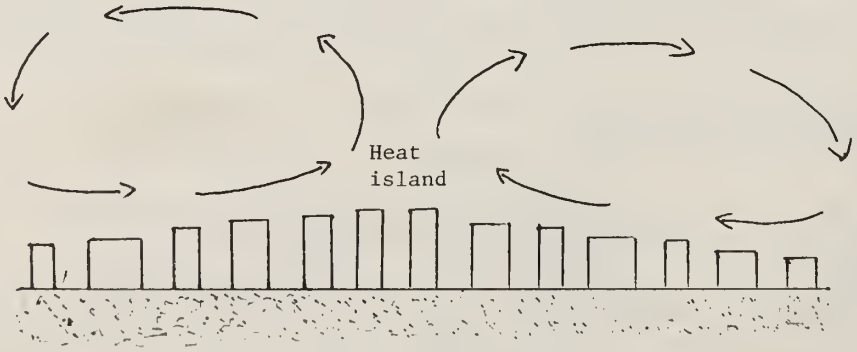


Fig. 7-6. The effect of an urban heat island on the wind field

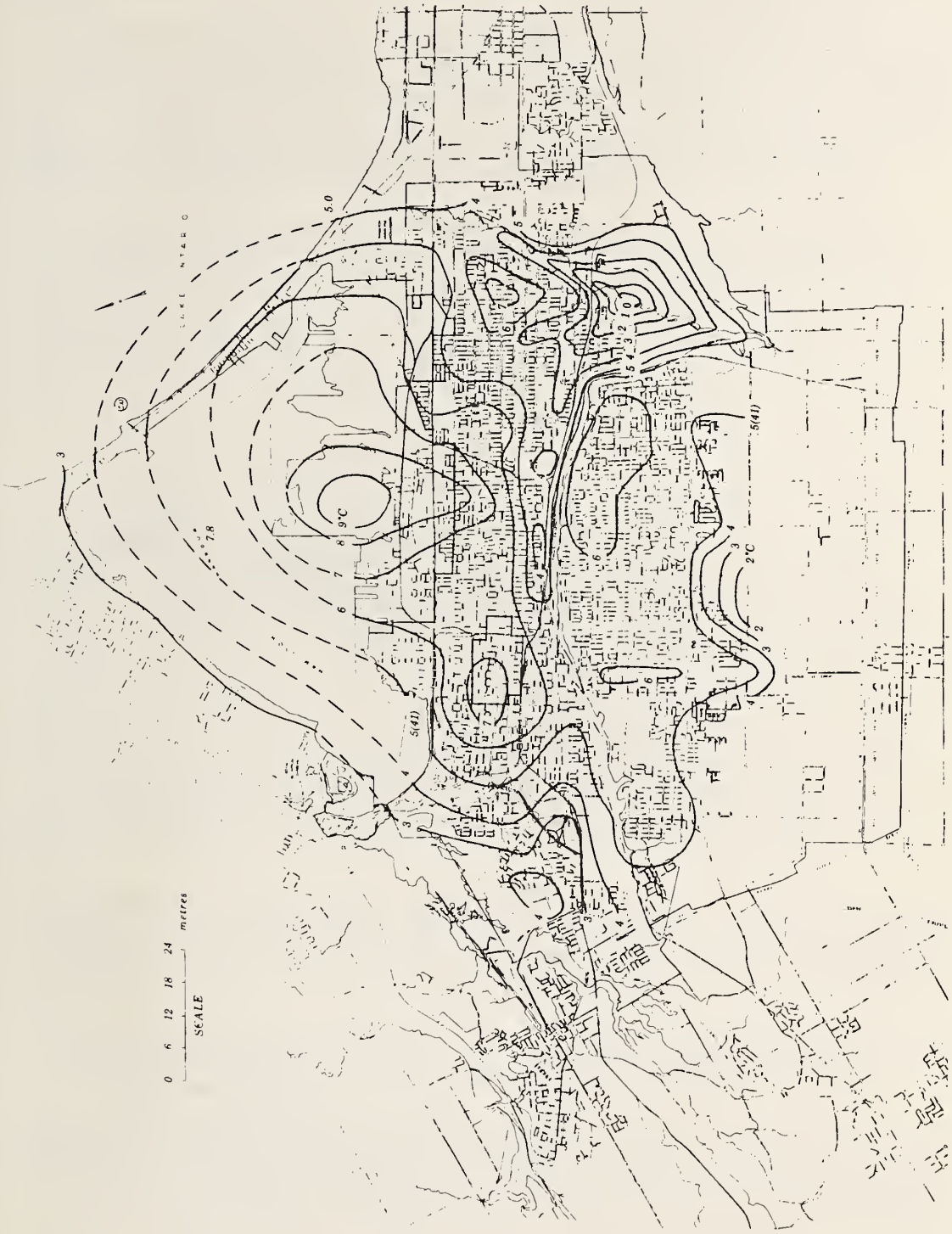


Fig. 7-5. Distribution of temperature in Hamilton, at 1900 EST on Tuesday, November 22, 1966

THE JOINT OCCURRENCE OF TWO OR MORE MESOSCALE WIND FIELDS. Urban areas are often located on coastlines or in river valleys; and they may contain well-marked topographic features such as ravines (Toronto), an escarpment (Hamilton) or a hill (Montreal). In all of these cases, the mesoscale wind fields are complex, requiring special field studies to elucidate.

Here, only one example is cited, the pattern of maximum temperatures in Metropolitan Toronto on July 30, 1965, a day when the macroscale wind field was light variable. See Fig. 7-7 (Munn *et al.* 1969). A well-developed lake breeze caused a strong temperature gradient near the lake. Two mesoscale features are of particular note:

1. The centre of the urban heat island is displaced northward by the lake breeze, being located on the northern edge of the built-up area, rather than downtown.

2. The cooling effect of the lake breeze penetrates up the Humber and the Rouge Rivers farther inland than elsewhere, the valleys providing preferred pathways.

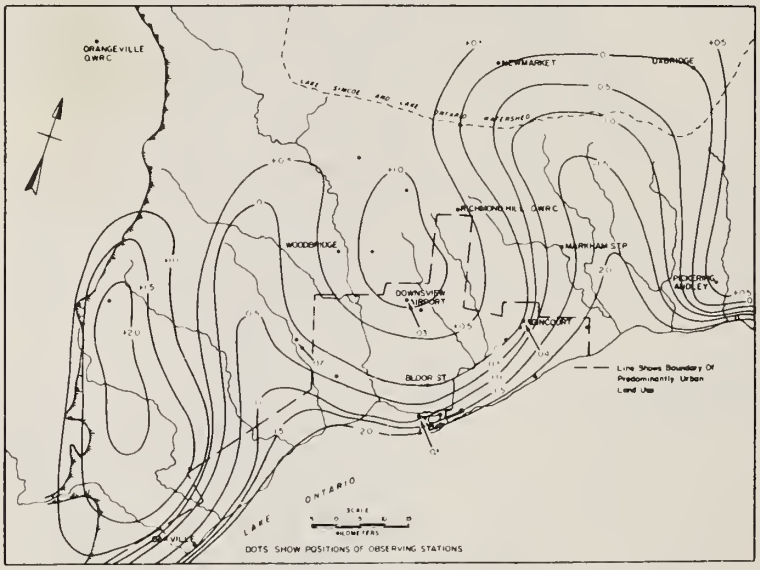


Fig. 7-7. Departure of maximum temperature from Bloor Street (maximum 22°C) on 30 July 1965 under a calm macroscale wind. The arrows indicate the speed (m sec^{-1}) and direction of the 10 m wind at 1300 EST. (Munn *et al.* 1969).

MICROSCALE PATTERNS. The mesoscale circulations described above occur also on the microscale, but the features are more diffuse and intermittent. However, sharp discontinuities in the values of the meteorological elements occur, for example, at the edges of parking lots and of urban parks.

7.1.4 OTHER MESOSCALE EFFECTS

There are three other mesoclimatic effects that should be mentioned.

IN SPRING AND SUMMER. When warm air blows across cool water, a temperature inversion is formed, and there may be mist or fog. The fog dissipates inland but visibility may be rather poor near the shore. This situation occurs frequently in Halifax and Saint John.

IN WINTER. (1) When cold air blows across warm water, the wind becomes very gusty, clouds form, and squalls may produce locally heavy falls of snow. This is enhanced by upward sloping land, which may trigger orographic squalls. Buffalo, New York has many lake-effect "blizzards"; Toronto is on the wrong side of the lake to experience this phenomenon very often.

(2) On days when the temperature is near the freezing point, precipitation may fall as rain near the coast and snow inland. The net effect can be substantial in a city such as Vancouver (snowfall ranging from about 40 cm at the airport to more than 500 cm on Grouse Mountain). Even in Toronto, the winter snowfall totals can vary considerably across the city: see, for example, Fig. 7-8 (Potter 1961).

7.1.5 CLIMATIC ADAPTATION

A vegetative cover, particularly a forest, regulates climate to a large extent, offering protection from gales, summer heat, and unseasonable frost. If a rectangle of forest is cut down, a frost pocket may develop, preventing regeneration of the trees. Similarly, the edge of a forest or woodlot acts as a buffer against the effects of weather extremes, and against the harmful effects of pollution.

Up until the eighteenth century, the vegetative cover of North America was more or less in equilibrium with its environment, and could sustain climate extremes. The cutting of forests and the ploughing of fields changed the heat balance at the earth's surface, generally increasing the vulnerability of vegetation to cold and wind. Added to this was the fact that many new species of plants, such as tobacco and ornamental shrubs, were introduced into regions far from their normal climatic habitats. These effects are being combatted to an extent through irrigation, shelter belts and frost protection measures (smoke pots, water sprays, etc.).

7.1.6 FIELD SURVEYS

The spatial patterns of mesoclimate can be estimated in several ways.

METEOROLOGICAL SURVEYS. Measurements should be taken during periods of clear skies and light macroscale winds, when mesoscale flows are likely to be most strongly developed. Sling psychrometers (wet- and dry-bulb hygrometers) can be used to obtain temperature and humidity, and the wind can be estimated with a portable hand anemometer. For a small ravine, the investigator can simply walk down the slopes. For larger areas, bicycles or automobiles may be used, with observations being taken at predesignated points over a two to three-hour period during steady weather conditions (not near sunrise or sunset). The observer must take measurements both coming and going, averaging the two values obtained at each point in order to remove the effects of an area-wide rise or fall in temperature that may have taken place during the traverse. For small valleys and ravines the wind flows can sometimes be visualized by watching the behaviour of smoke generated by burning oily rags.

NATURAL INDICATORS OF CLIMATE. Many natural indicators of micro- and mesoclimatic patterns are available. These include:

(a) Areal patterns of wet and dry patches a few hours after a rainfall;

(b) Areal variations in snowfall and snow-melt patterns;

(c) Areal variations in soil moisture;

(d) Areal variations in the dates of first blossoms on fruit trees, and of other well-marked phenological events: (Fig. 7-9 is an example, showing the effect of the urban heat island on the time of blossoming of apple trees in Cologne (Kalb 1962).)

(e) Variations in the areal extent of early autumn frosts;

(f) the orientation and thickness of rime ice on tree twigs (an indicator of the wind field on damp frosty nights, when rime ice forms on the windward side of twigs);

(g) Variations in ecological indicators: species distribution; heights of trees; the presence of physical deformations; the direction of tilt of trees (an indication of the prevailing wind);

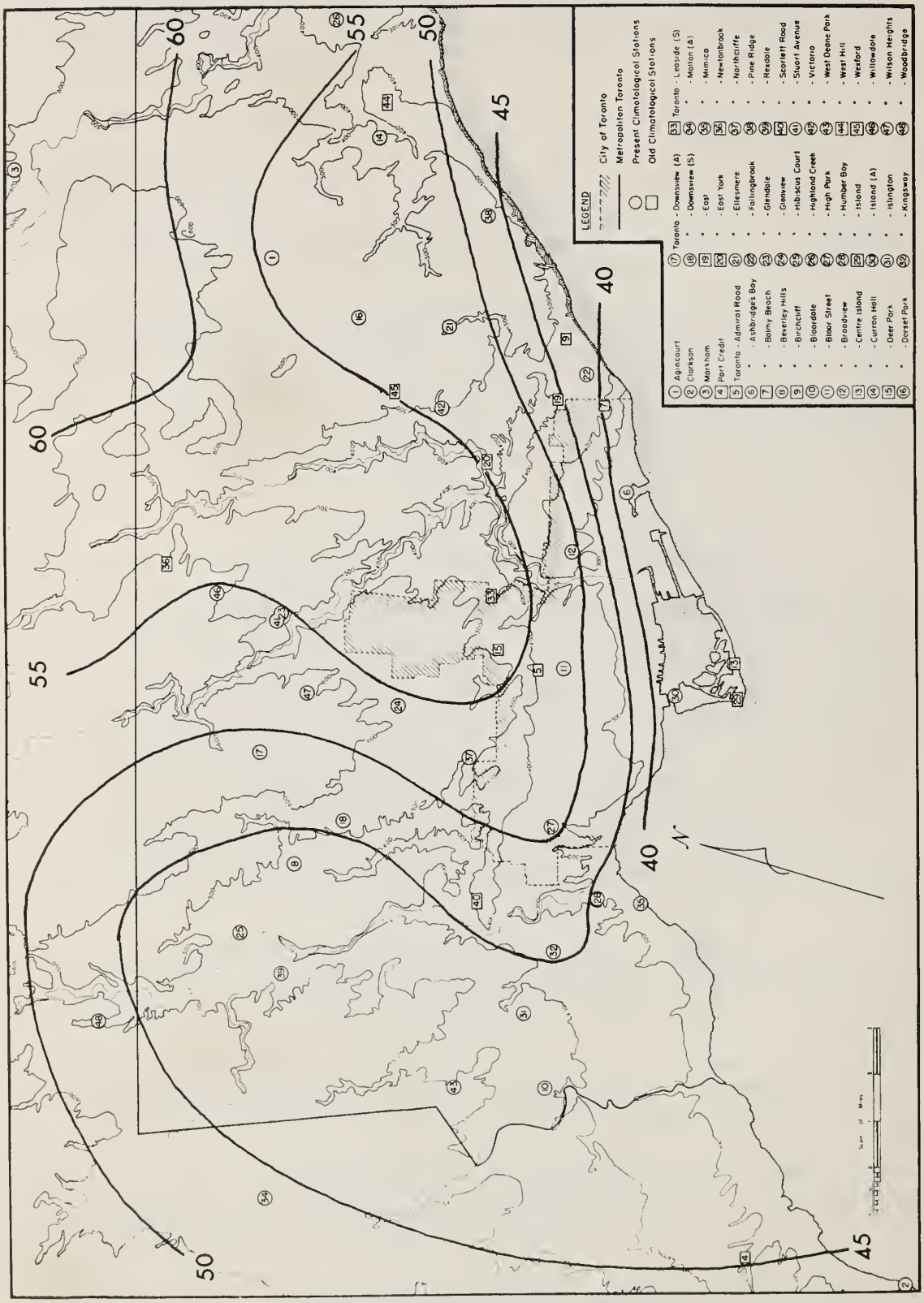


Fig. 7-8. Average winter snowfall (inches) in the Toronto region (Potter 1961)

(h) Visual observations of the movement of chimney plumes, and of the fluttering of flags.

With experience, a field naturalist can infer the meso- and microclimate, sometimes in more detail than could ever be achieved with expensive meteorological instruments.

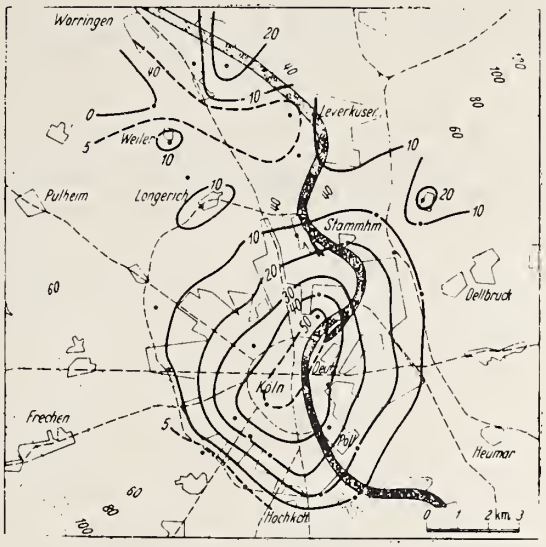


Fig. 7-9. Isopleths of the percentage of open apple blossoms on May 7-8, 1956 in Cologne (Kalb 1962)

SUPPLEMENTARY DATA SOURCES

Climatological data and information can be obtained by writing to:

Atmospheric Environment Service,
4905 Dufferin Street,
Downsview, Ontario M3H 5T4 (telephone (416) 667-4614)

It is preferable to describe the application intended rather than to ask for specific data. The Atmospheric Environment Service can then evaluate the problem and determine the relevant data.

Meteorological instruments can be purchased from:

Science Associates Inc.,
230 Nassau Street,
Box 230,
Princeton, N.J. 08540

This company specializes in instrumentation that would be suitable for field naturalists and similar environmental groups.

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Weatherwise. American Meteorological Society, order from Heldref Pubs., 4000 Albermarle Street, N.W., Washington, D.C. 20016 (6 issues per year, $12.00 per year to individuals).

Weather. Royal Meteorological Society, order from Royal Meteorological Society, James Glaisher House, Grenville Place, Bracknell, Berks. RG12 1BX, U.K. (12 issues per year)

7.2 SOILS

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7.2.1 INTRODUCTION

It is salutary to remember that the present well-being and future survival of the human race, and of many species of wildlife, are utterly dependent on the top 10 cm of soil. Around the world this minute fraction of the earth's crust is being subjected to tremendous degradational pressures: unrestricted mining of nutrients; severe physical decline caused by ill-advised tillage practices or mechanical compaction; wind and water erosion; salinization caused by poorly managed irrigation projects; contamination by a wide range of industrial and domestic wastes. The key position of soils in natural systems at the interface between the geosphere, hydrosphere, atmosphere and biosphere makes their study essential in any form of environmental impact assessment.

Soil is a familiar substance to most people yet its nature and characteristics are surprisingly difficult to define. Soil has been defined as "a complex combination of mineral and organic matter, air and water", but so is the human body. Much of this difficulty arises from its central role in natural systems. This in turn has led to its study as a legitemate and integral part of many disciplines: geomorphology, geology, botany, engineering, agriculture - with diverse and to some extent incompatible approaches. The problem is accentuated by the difficulty of delimiting soil. As an example we might seek to determine at which moisture content does watery mud become muddy water, or at precisely which stage of weathering does bedrock become soil. The difficulty is compounded because soil is a dynamic body which evolves in response to environmental influences until it reaches an equilibrium state. This dynamism has plagued attempts to devise something akin to a Linnéan classification for soils; unlike the situation with flora and fauna, the individual "species" in pedology may evolve into something totally different within a matter of a few years.

For practical purposes, soil may be defined as a *complex combination of mineral and organic matter, air and water, differentiated into layers of varying depth and distinctness by the varying interaction of climatic processes and organisms, but which collectively is distinct in character from underlying crustal material.* The four basic components, therefore, are mineral and organic matter, air and water. None is constant in time, but mineral matter changes relatively slowly, organic matter more rapidly, while the moisture and air components are both highly variable in amount and composition, changing in response to atmospheric and biologic factors. The components may be separated for analysis, but it is difficult to do this without causing changes; for many purposes, therefore, soil must be studied and analysed *in situ* in the field.

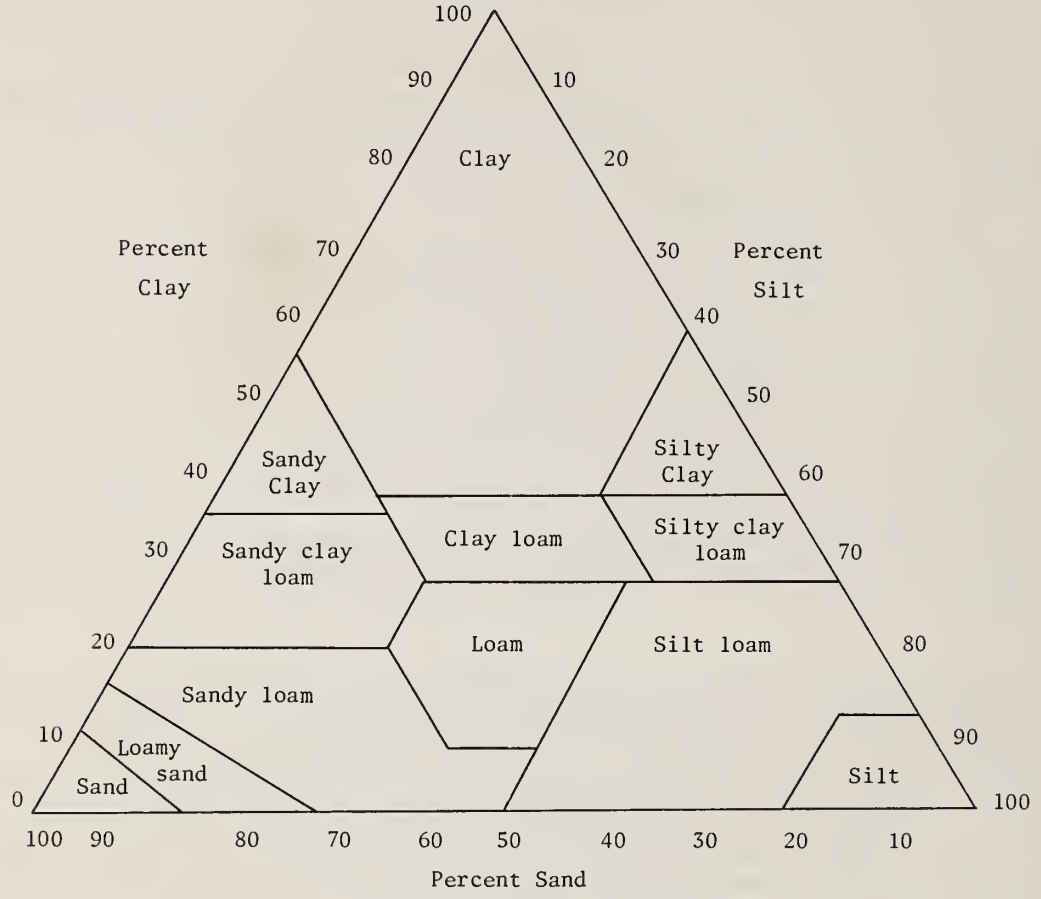
7.2.2 MINERAL MATERIAL

The mineral component of soil may vary greatly in chemical and mineralogical composition in response to variations in parent material and the nature of weathering and pedogenic processes active. Mineral particles also vary in size influencing many of the more important soil properties. A basic distinction is made between coarse stones and gravels, greater than 2 mm in diameter, and finer material which is split into several categories, most commonly:

Sand	Coarse sand	0.2 - 2 mm diameter
	Fine sand	0.05 - 0.2 mm diameter
	Silt	0.002 - 0.05 mm diameter
	Clay	less than 0.002 mm diameter

The relative percentages of sand, silt and clay constitute the *mechanical composition*, which is a highly significant property affecting, for example, the soil's erosion resistance, its capacity to hold moisture and its suitability for

root penetration. The determination of this composition by *mechanical analysis* is the most basic and widely performed soil test. Sand, silt and clay can be combined in an almost infinite variety of proportions, but the differences between some of these combinations are slight, and so for practical purposes soils are classified into *textural categories*. Soils of the same texture have similar mechanical compositions and properties. The number and name of the textural categories varies, but by far the most widely-used system is that of the U.S. Department of Agriculture which recognizes twelve categories (Fig. 7-10)



	Wet state	Rolling between fingers
1. Clay	Very sticky, plastic	Gives long threads
2. Loam	Plastic, not sticky, cast can be polished	Gives threads with difficulty, which cannot be looped.
3. Sandy loam	Slightly plastic. Perceptible sand.	Threads form with great difficulty
4. Loamy sand	Cannot be rolled into threads, but has slight cohesion	
5. Sand	No cohesion	

Fig. 7-10. Triangular textural diagram (based on that used by the United States Department of Agriculture) and guide for field identification of certain classes.

Apart from the basic size distinction, the most important separation point is at 0.002 mm diameter, which separates non-colloidal silt and sand from colloidal clay. Silt and sand are predominantly produced by physical weathering while the colloidal fraction represents the results of complex chemical processes which produce a variety of *clay minerals*, principally kaolinite, montmorillonite, illite and chlorite though the proportions may vary greatly. The clay fraction gives important properties to the soil, such as the ability to absorb and retain water, the capacity to shrink and swell and the properties of plasticity and cohesion. It is also the chemical active fraction of the soil which has the capacity to retain certain nutrient *cations* and which, therefore, plays a critical role in soil fertility.

The ultimate particles or *textural separates* identified by mechanical analysis may be found in the soil in a dispersed or *single grain* state. Much more commonly they are combined and cemented into groups or *soil aggregates* which vary greatly in size, shape and resistance to dispersion. Soil aggregation is one of the most important soil properties for it strongly influences resistance to erosion by wind or water (*soil erodibility*) and the ease of tilling soil, and, through its control on air space, the available storage capacity for water and the ease with which water passes through the soil (*permeability* or *hydraulic conductivity*).

7.2.3 ORGANIC MATTER

The organic fraction of the soil may vary from near 0 to almost 100% of the solid soil material, but most commonly it is not more than 50% by weight of the topsoil and drops rapidly with depth. The organic fraction is vital as a major source of phosphate and sulphur and almost the sole natural source of nitrogen. It provides the main energy source for micro-organisms and is, therefore, essential to biochemical activity in the soil. It also has a major influence on soil aggregation and other important physical properties of the soil.

The organic matter consists of partially decayed and partially resynthesized plant and animal remnants. It includes both structured, identifiable remnants and diffuse colloidal *humus* in very variable amounts. Both contribute to the physical character of the soil, humus being particularly important because of its high absorptive capacity for water and its role as an aggregate cement. It is also extremely active chemically and has a very high capacity to adsorb nutrient cations, and, therefore, contributes greatly to soil fertility.

The character, total amount and distribution of organic matter within the soil vary greatly in response to variations in (a) the mode of addition (e.g. by leaf fall or by root decay); (b) the activity of soil fauna such as earthworms which intermix organic and mineral matter; and (c) the activity of micro-organisms which cause organic decay. In the anaerobic conditions of saturated boggy soils, for example, fewer micro-organisms are present, retarding decay and permitting organic matter to accumulate into peat deposits. Where the soil is well-drained and aerated, organic matter is rapidly broken down to its components in which form it ultimately leaves the soil by plant uptake, leaching or gaseous diffusion. The organic fraction, therefore, represents a balance between additions of undecayed organic remnants and withdrawal of decomposition components. If addition occurs more rapidly than withdrawal, organic matter accumulates, eventually producing peat; if it occurs more slowly, as is the case in many agricultural soils, the organic content drops, with repercussions on both the fertility and physical properties of the soil.

7.2.4 SOIL SOLUTION

The soil solution is the liquid held within pore space in the soil, which contains a diverse array of salts in solution and is, therefore, important to plant nutrition. The liquid content also closely influences certain physical properties such as *shear strength*. The total pore space or *void ratio* varies greatly, depending on particle size, shape and packing, but is seldom less than 50%. This may be occupied totally by air or liquid, but most commonly by both. Immediately

after prolonged rainfall, all pore space may be filled with water, i.e. the soil is saturated. After a few days, water held loosely in large non-capillary pores will have drained out and the soil is said to be at *field capacity*. Over a long period of time, the moisture content will drop further, primarily due to evapotranspiration*, until plants can no longer obtain an adequate moisture supply from the soil, which is now at *wilting point*; this is not a constant, but varies with the plant species involved. The actual soil moisture content at saturation, field capacity and wilting point depends on pore characteristics and is soil specific. For example, the moisture content at field capacity for a heavy clay with few large pores might be 50%, while that for a coarse sand might be only 25%.

7.2.5 SOIL AIR

The amount of soil air is dependent on the void ratio and the moisture content. It differs from the free atmosphere by having a much higher carbon dioxide content, being most commonly saturated with water vapour, and by its lack of homogeneity, as all pore space is not freely connected. The exact composition depends on the organic matter and on the level of microbial activity; thus marked variations occur within the soil in response to microbial density, and in the soil as a whole in response to such factors as temperature.

7.2.6 SOIL DEVELOPMENT AND CLASSIFICATION

The first stage in the development of soil is the transformation of parent material by weathering. The parent material may be bed-rock *in situ* or it may be a surficial deposit such as alluvium or glacial till which has undergone diverse weathering, erosion and deposition. The product of weathering, or *weathering complex*, is thus highly variable, depending both on the nature of the parent material and the precise intermixture of physical and chemical weathering processes. These processes do not cease with the formation of the weathering complex, but their rate slows; visible change is progressively dominated by pedogenic processes which cause selective translocation and deposition of material within the weathering complex. Superimposed on this physical and chemical translocation is the variable addition of organic matter on and within the soil.

The net effect by pedogenic processes is that the originally more or less homogenous weathering complex becomes differentiated into a series of layers or *horizons* with quite distinct physical and chemical characteristics, some of which have had material removed, and some material added. These horizons are termed *eluvial* and *illuvial* horizons, respectively. Sometimes the differences between horizons are so marked that they can be observed easily in the field; sometimes they can be distinguished only by rather sophisticated laboratory analysis. The actual number of horizons differentiated will vary both with the soil type and with the sophistication of the analytical techniques used, and may number from two to more than a dozen. Collectively these horizons make up the *soil profile* which is the fundamental unit used in soil identification and classification.

The initial soil formed once plants colonize the weathering complex, the *skeletal soil*, has a relatively simple profile with little horizon differentiation. The skeletal soil undergoes rather rapid change in response primarily to water movement causing distinct horizons to appear. Eventually the changes become more and more subtle and indistinguishable until eventually all substances which can be moved under given circumstances will have been moved. At this stage the soil profile is in equilibrium with the *pedogenic factors* which controlled its development, which are respectively: parent material, climate, topography, organisms and time. It should be pointed out that this equilibrium or *mature* soil is probably a theoretical abstraction as the pedogenic factors probably never remain unchanged sufficiently long for a mature soil to develop. It is, however, a useful conceptual

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*water loss by evaporation from the soil and transpiration from vegetation.

framework for understanding the progress of soil development. Any change in the pedogenic factors will lead to disequilibrium and will generate further changes in the soil. In many areas it is possible to distinguish groups or *sequences* of soils which are related to one another by changes in one pedogenic factor. So one can identify lithosequences, climosequences, toposequences, and so forth. This concept has proven particularly valuable in understanding the relationships between soils within restricted areas, such as, for example, one river valley.

There is no universal agreement about the methods which should be used in classifying soils. In fact for years there has been lively debate as to whether they should be classified primarily to allow more effective soil management or to provide greater understanding of soil as a natural system. Essentially the core of the problem is whether classification is simply an arbitrary framework for ordering of knowledge, or a recognition of natural ordering inherent in all natural systems. In response to this continuing controversy, many classification systems have appeared, often in response to the needs of individual countries. The Canadian classification system gradually developed over the past fifteen years distinguishes 8 major soil *orders*, which are split into 23 *great groups* (Table 7-1), 165 *sub-groups*, approximately 1000 *families*, 3000 *series* and 4000 *types*.

Table 7-1. Outline of the Canadian soil classification system

Order	Great Group	
Chernozemic	Brown	11 sub-groups
	Dark Brown	11 sub-groups
	Black	11 sub-groups
	Dark Gray	10 sub-groups
Solonetz	Solonetz	6 sub-groups
	Solod	5 sub-groups
Luvisolic	Gray Brown Luvisol	5 sub-groups
	Gray Luvisol	8 sub-groups
Podzolic	Humic Podzol	4 sub-groups
	Ferro-Humic Podzol	6 sub-groups
	Humo-Ferric Podzol	8 sub-groups
Brunisolic	Melanic Brunisol	4 sub-groups
	Eutric Brunisol	6 sub-groups
	Sombric Brunisol	3 sub-groups
	Dystric Brunisol	6 sub-groups
Regosolic	Regosol	6 sub-groups
Gleysolic	Humic Gleysol	7 sub-groups
	Gleysol	7 sub-groups
	Eluviated Gleysol	4 sub-groups
Organic	Fibrisol	13 sub-groups
	Mesisol	11 sub-groups
	Humisol	11 sub-groups
	Folisol	2 sub-groups

The soil type, identified by the name of its locality, is the smallest practical unit for reproduction on maps and scales of 1:63360 or 1:31680, which are common production scales for soil surveys. It is possible in the field to identify more localized variations within one soil type, and *soil phases* are recognized which identify characteristics such as shallowness, stoniness or the removal of some horizons by erosion. In some cases maps at very much larger scales are used (up to 1:2534), for such purposes as planning the location of tile drains within an individual farm.

The system of classification used in Canada, like those of soil surveys in many other countries, is essentially a natural one which attempts to incorporate all

observable properties of the soil. This approach has been criticized on the grounds that much of the information produced is of little practical value. It has been suggested that it would be preferable to classify and map soils on the basis of one or a few properties which govern their practical use. There is some justice in this criticism and some soil surveys, such as the National Soil Survey of Ireland, have responded by producing maps based on practical attributes, such as drainage status, as well as the general classification. The main difficulty is that soil information is relevant to so many human activities that it would be impossible to produce an adequate variety of maps; most surveys like those in Canada, therefore, have compromised by publishing a general map and including abundant advisory and interpretive material in an accompanying memoir.

7.2.7 ACQUISITION AND USE OF SOIL INFORMATION

Soil surveys are a recent development and though national and provincial authorities have made rapid progress, there remain large areas of Canada for which only rudimentary information is available. Most of the survey information is oriented towards agriculture though in recent years a number of special purposes surveys, such as those for the proposed Mackenzie Valley pipeline, have been carried out.

In attempting to use soil survey information for urban area studies, a problem arises as most surveys make no attempt to map within developed areas. Directly applicable survey information is, therefore, likely to exist only where urbanization has spread into previously mapped farmland, as in the Scarborough Borough, of Toronto. Nevertheless, existing surveys do provide a good regional framework for extension into detailed urban studies. Exactly how these should be approached depends on the objectives, and on the character of the area. If it is a river valley, a further problem arises as most surveys classify valley soils as *undifferentiated complex* or as alluvial *regosols*. In the first case, clear differentiation of horizons is prevented by the instability and mixing on slopes, and rapid lateral variations in the pedogenic environment make map differentiation at common survey scales impossible. In the second case, frequent disturbance of pedogenesis by deposition of new alluvium prevents development of the soil appreciably beyond the skeletal stage.

7.2.8 CARRYING OUT A SURVEY

In the absence of useful and applicable published soil survey data, it may be necessary to carry out a survey. This may be directed towards examination and classification of the soil as a part of a natural system, or as a basis for predicting its influence on, or response to, human activities. In the first case it is appropriate to base the survey on procedures similar to those employed by Canadian governmental soil surveys, the object being to produce a map and accompanying report. The first stage is to determine at which points the soil will be examined, which may be determined by *random* or *stratified* sampling. The essential advantage of random sampling is that it assumes no prior knowledge of the area or factors controlling soil development, while stratified sampling may involve both. The advantage of the latter is that adequate information may be derived from a smaller number of sampling points. A third technique, particularly appropriate to river valleys, is the *transect profile* in which samples are collected along one or more transverse sections across the valley. This is particularly useful in attempting to establish sequential relationships between soils, as in a *hydrosequence* or *hydrologic association*.

An initial quick examination of the soil at each sampling point may be made using an *augur* to determine which points are most appropriate for a more detailed study of "typical" soils. If the area is not too large, it may be possible to carry out such a study at each sampling point. As a complete detailed study takes 3-4 hrs, time is the limiting factor. At points chosen for detailed study, a pit is dug to permit soil profile examination. The standard procedure for soil profile examination has been described in detail in a number of publications (Soil Survey Staff 1951; Canada Department of Agriculture 1974; Clarke and Beckett 1974). Basically it has

two stages: the first requires description of the characteristics of the land area or *site* of which the profile is representative; the second involves identification and description of each horizon from the surface down to the undifferentiated parent material. The site is essentially an area within which major pedogenic factors are essentially homogeneous, and on which soil can, therefore, be expected to show similar homogeneity. Depending on the complexity of the area, it may vary from several square metres to many square kilometres. The site description allows the profile information to be placed in a systematic framework. A skeletal check list for site and profile description is shown in Table 7-2.

Table 7-2. Ckeck list for field examination of soil profiles

1. Site description

(a) Name of locality; Profile number; Map reference.
(b) Topographic data:
1. Elevation; 2. Slope angle, shape; 3. Aspect; 4. Area of site;
5. Surface micro-relief.
(c) Vegetation:
1. Dominant species; 2. Size and age; 3. Canopy cover; 4. Health or condition of plants.
(d) Parent material.
(e) Site drainage:
1. Free; 2. Seasonally wet; 3. Permanently wet; 4. Subject to waterlogging.
(f) Climatic data.
(g) Evidence of interference, e.g. soil erosion, profile truncation, ploughing, changes in soil drainage, contamination by soot, dust, etc.

2. Profile description

For each horizon from surface to parent material following data should be logged.
(a) Horizon number.
(b) Horizon thickness and variations.
(c) Colour (Munsell notation) and colour pattern.
(d) Texture (by hand or by mechanical analysis).
(e) Stone fabric:
1. Size and variety of sizes; 2. Quantity; 3. Type and state of weathering of rock.
(f) Structure:
1. Pattern of aggregation *in situ* (7 categories); 2. Size of aggregates;
3. Stability of aggregates.
(g) Organic matter:
Type and intermixture of humus.
(h) Roots:
1. Size variation; 2. Quantity; 3. Nature.
(i) Drainage:
1. Excessive; 2. Free; 3. Impeded; 4. Poor.
(j) Acidity:
pH value to first decimal point.
(k) Soil fauna:
Verbal assessment of abundance of identified species.
(l) Secondary chemicals:
Any present in horizon, e.g. calcium carbonate, iron oxide concretions, manganese dioxide, sodium chloride.
(m) Sharpness and clarity of boundary with next horizon.

Once the profile description is complete for each sample point, it will be possible to classify the soils into a number of *mapping units*, the number of which depends essentially on the scale of the map to be produced and on the soil complexity. Mapping unit boundaries can then be placed on the map by interpolation, although more acurate boundaries may be obtained by using site boundaries. In some cases it may be necessary to "prove" a transitional boundary by further sampling or auguring.

The simple field survey requires little in the way of special equipment. An Abney level or Brunton compass is needed for site slope determination, and for the profile, a tape measure, a soil colour chart (the Munsell chart is standard but expensive; a perfectly acceptable Japanese alternative is available at about 1/7th the cost), a pH meter (or a colorimetric pH kit, which is much less expensive) and a bottle of dilute hydrochloric acid to test for the presence of free carbonates. Basically the key to good profile examination is experience in identifying characteristics as indicators of certain pedogenic processes or of past human disturbance, such as charcoal layers or plough pans. Particularly in valley studies, it may be necessary to interpret whether a soil profile is complete, or has been *truncated* by erosion. Likewise in some situations two or more cycles of soil development may have occurred to produce *bisequa* or *polysequa* soils.

The sort of survey described may well be adequate for many purposes although clearly it would be improved by having full chemical and physical laboratory analysis. Facilities and expertise necessary are found in many universities or professional material-testing laboratories. A description of most of the common tests together with a discussion of necessary equipment can be found in the excellent compendium edited by Black (1965).

In some cases it may be desirable to go beyond the basic soil survey and prepare an additional survey for a specific purpose. For example, it may be desirable to map variations in soil erodibility in order to assess the potential impact of cutting trees. Such a survey is comparatively easy, essentially involving isolation of a simple, easily measured soil property as an index of soil erodibility. Many properties have been proposed, but the most suitable and practicable appears to be a simple measure of the stability of soil aggregates using a wet-sieving apparatus (Bryan 1969; 1976).

Another specialized survey with many applications, but particularly in hydrologic forecasting involves mapping the ability of the surface soil to absorb water or its *infiltration capacity*. This requires measurement with a simple *ring infiltrometer* either with or without a sprinkler as a water source. A related survey of soil permeability is rather more difficult to carry out, but may have many applications such as, for example, assessing the potential effect of subdivision development based on septic tank sewage treatment. Another special survey might involve commonly sought information on soil *bearing capacity* or *compactability*, as a tool in trail planning or even in building construction. Full analysis of such properties requires the facilities of a soil engineering laboratory, but a reconnaissance survey can be carried out with simple readily-obtainable instruments such as *soil penetrometers*. Information on soil stability and the potential effects of, for example, road-cutting or bank erosion on slope stability is often of great interest. In this case, however, analysis is complex and requires very careful data collection and sample testing in a well-equipped soil engineering laboratory, and so is clearly beyond the range of even a well-informed amateur.

7.2.9 CONCLUSION

The brief discussion of soil surveying is designed to provide only a skeletal framework. Obviously the value of information obtained will increase as the surveyor becomes more experienced. Even a lone surveyor working without laboratory facilities can produce excellent data but if a public controversy of any scale is likely to arise or if the survey is likely to be challenged in environmental impact hearings, then the field study should be supported by laboratory analyses. Many of the analyses are rather standard and facilities may be found in laboratories of most university departments of soil science, agriculture, forestry, geography and occasionally in geology. In the case of engineering properties such as shear strength, assistance should be sought from university soil engineering departments.

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7.3 HYDROLOGY

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7.3.1 INTRODUCTION

The study of the occurrence, distribution, movement, and properties of water, and their environmental relationships is the science of hydrology. Because of the influence of water in the micrometeorology, soils, vegetation and wildlife, knowledge of the hydrology of a natural area is extremely important. Although the collection of many types of hydrologic data requires technical expertise and the use of sophisticated and expensive equipment, useful information can be collected by the layman who has an understanding of some of the basic principles of hydrology.

7.3.2 THE HYDROLOGIC CYCLE

The proportion of the total world supply of water in the atmosphere amounts to only about 0.035%. This amount is considerably less than the mean annual global precipitation of 857 mm. A process must, therefore, exist whereby water can be returned to the atmosphere after falling on the earth. This process of moisture circulation is known as the *hydrologic cycle* (Fig. 7-11). The driving mechanism of this cycle is energy from the sun.

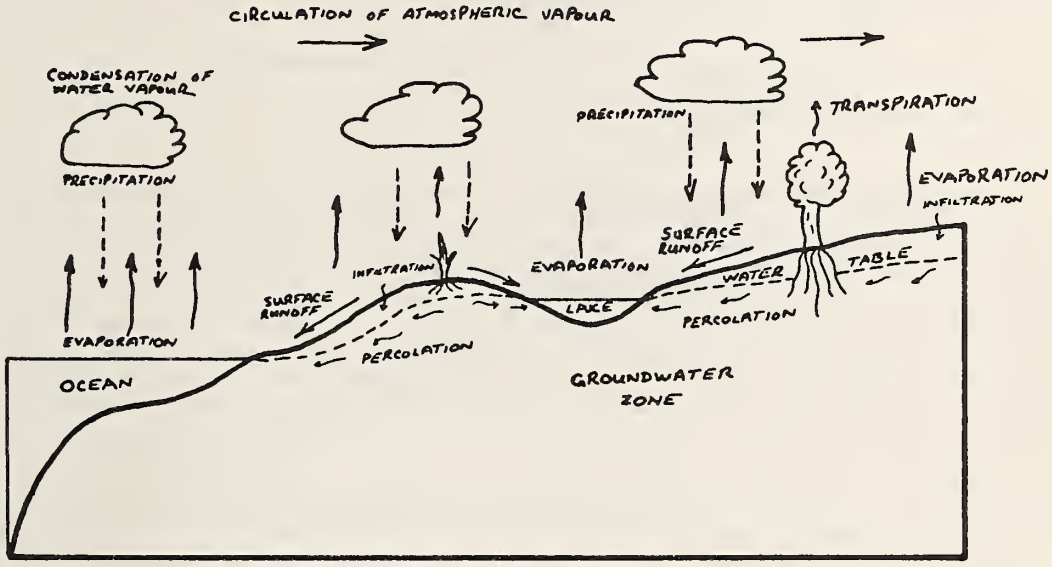

Fig. 7-11. The hydrologic cycle

When atmospheric conditions are favourable, water vapour condenses, forms clouds, and is ultimately returned to the surface of the earth, mainly in the form of rain or snow. Some of this precipitation will be *intercepted* before reaching the ground by vegetation and various structures from which it will evaporate and be returned to the atmosphere. Precipitation that reaches the ground will either collect in depressions, pass into the ground (infiltrate), become surface runnoff, i.e. flow across the ground surface to a defined stream channel, or, in the case of snow, be stored temporarily on the surface.

Some of the water that infiltrates the ground will be stored near the surface in the soil zone where it can be utilized by vegetation. Plants themselves will return some of this water to the atmosphere through the process of *transpiration*. Because soils have limited water holding capacity, excess water will move downward

(percolate) through the *zone of aeration* to the *zone of saturation* where it is stored as *groundwater* (Fig. 7-12). In the zone of aeration the spaces between the mineral grains (pore spaces) that comprise the ground material are occupied by both air and water. The pore spaces in the zone of saturation are filled with water. The boundary between these two zones, called a *free water surface* (water table), fluctuates in response to an increase or decrease in groundwater storage.

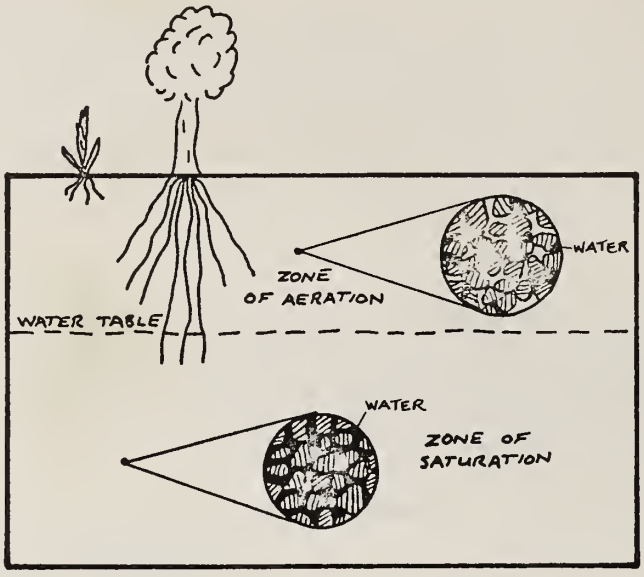

Fig. 7-12. Ground moisture zones

Some areas within the zone of saturation are better suited for storing and transmitting water than others. These zones are called *aquifers*. Suitable aquifer materials are those in which the pore spaces between the individual grains of soil or rock are relatively large, and through which water can flow easily. Such materials are said to have a high *specific yield* and *high permeability*. Natural materials that meet these criteria are sands and gravels, sandstones, and some limestones. In contrast, clays and shales have low specific yields and permeabilities, and, as such, make poor aquifers but good confining (impervious) layers (aquicludes). An aquifer in which the water is confined under pressure by aquicludes is termed *artesian*. The relationship between aquifers with a free water surface and artesian aquifers is shown in Fig. 7-13. When a well is drilled in the former, water will rise in the well to the level of the free water surface. In the latter, the water will rise under pressure to some point above the upper confining bed. This level is known as the *piezometric surface*. In places where the piezometric surface lies above the ground, surface water will flow from wells under its own pressure.

Natural discharge of groundwater occurs where aquifers intersect the ground surface. Flow in many streams during periods of drought is maintained by groundwater flow (base flow) from water table aquifers intersecting the stream banks.

Groundwater is also discharged along the walls of ravines, either as a concentrated flow (spring) or as a seepage line. In cases where groundwater is discharged at several levels in a ravine wall, the top level is associated with a water table aquifer, and the bottom levels are artesian aquifers (Fig. 7-14).

Surface runoff and base flow are collected by networks of channels which convey the water to lakes or the ocean. During this transport process and thereafter, the water is subjected to evaporation and returned to the atmosphere.

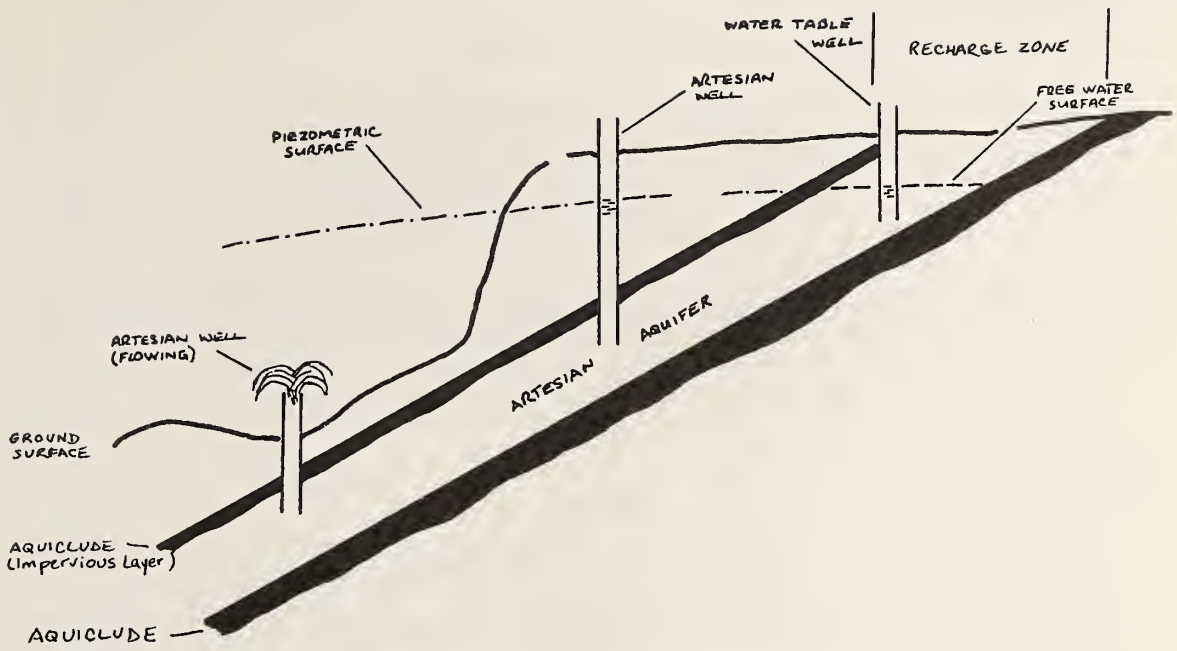

Fig. 7-13. Relationship between water table aquifers and artesian aquifers

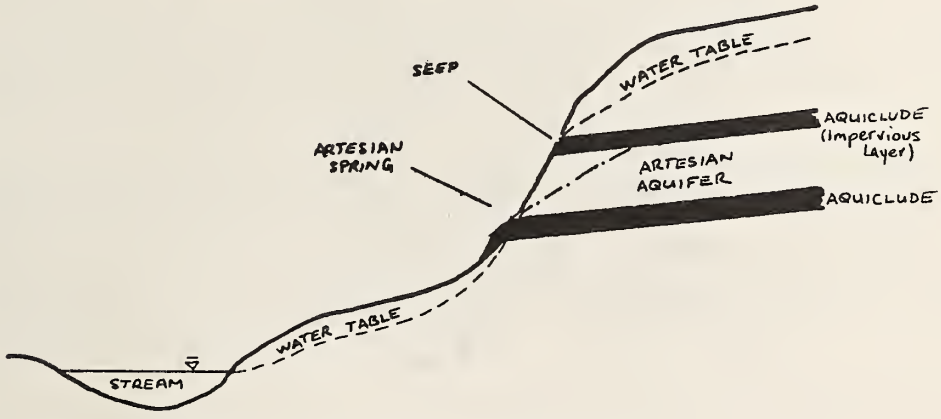

Fig. 7-14. Groundwater discharge along a valley side

The hydrologic cycle can be represented by the following equation:

$$R = P - ET \quad (1)$$

where R = total runoff reaching stream channel including base flow;
P = all types of precipitation;
ET = evaporation and transpiration losses.

7.3.3 THE DRAINAGE BASIN

A framework for the study of the hydrologic characteristics of an area is provided by the *drainage basin*. A drainage basin is the area drained by a particular stream or river system. Synonymous with this term are *catchment area* and *watershed*. Drainage basins are separated from one another by drainage *divides* (heights of land). The drainage basin is a dynamic system that is continually responding to change,

whether that change be natural or man induced. Within it are many subsystems - valley slopes, stream channels, soils, plant communities, etc. - that are closely related and collectively describe its unique character.

The first step in a study of a drainage basin or part thereof involves the preparation of a suitable base map in which information can be plotted. Its areal extent should be defined as precisely as possible through the use of large-scale topographic maps and air photos. Most of the large urban areas in Canada have been mapped at a scale of 1:25,000. This scale is large enough for drainage basins over 5 km^2. For smaller basins, adequate definition will usually require field mapping with a plane table, surveyor's level, and air photos.

The boundary of the drainage basin is drawn as a line that passes through the highest points between it and adjacent basins (Fig. 7-15).

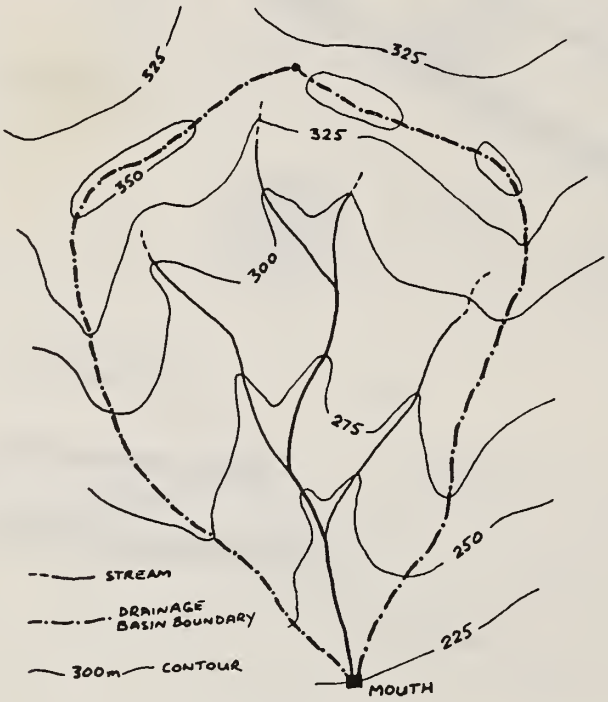

Fig. 7-15. Delineation of a drainage basin boundary

The characteristics of a drainage basin can be grouped into three categories for purposes of description - topographic, geological and vegetation. Only the first two will be considered in this section, since vegetation is discussed in Chapter 8.

7.3.4 TOPOGRAPHIC CHARACTERISTICS

Among the topographic characteristics that are useful for routine description of watersheds are: watershed area, shape, relief, slope, mean elevation, stream order, drainage density, and mean slope of the main channel. After establishing the drainage divide, the area of the basin can be determined in the following manner:

1. Overlay the basin with a piece of squared graph paper (10 ;ines per cm) and count the number of squares in the basin boundary.

2. Using the scale of the map, determine the number of squares in a known area, for example 1 km^2.

3. Determine the drainage basin area from the following equation:

$$\text{Basin area} = \frac{\Sigma S_T}{\Sigma S_k} \times A_k \qquad (2)$$

where ΣS_T = number of squares in the basin;
ΣS_k = number of squares in the known area;
A_k = known area in suitable units.

The *length* of a drainage basin (L) is the distance from the mouth to the most distant point (Fig. 7-15). *Relief* is defined as the difference in elevation between two points in the basin; for example, the relief in a particular part of the basin is the difference in elevation between the valley bottom and the top of the valley walls. Related to relief is the slope of the valley sides and the slope of the stream channels. The *slope* between two points is given by the equation:

$$\text{Slope} = \frac{\Delta Y}{\Delta X} \qquad (3)$$

where ΔY = the difference in elevation;
ΔX = the distance between the points.

Note: ΔY and ΔX must be measured in the same units.

Percent slope (% slope) can be obtained by multiplying Eq. 2 by 100. If maximum slopes in a drainage basin are to be determined from topographic maps, ΔY should be measured at right angles to the contour lines (lines of equal elevation).

In order to estimate the average slope over a drainage basin, or part of it, a minimum of 30 calculations of slope should be made and averaged. If slopes in a basin vary from one area to the next, it may be desirable to calculate an average slope for each sub-area.

Stream channel development in a watershed can be described in terms of the appearance of the network. If the network looks like the branches of a tree it is termed *dendritic* (Fig. 7-16). This type of network is typical of streams in areas underlain by unconsolidated (loose) sediments. In places where the stream channel is in direct contact with bedrock, the structure of the rock may be reflected in the channel pattern. For example, in limestone areas, the network is often characterized by right angle junctions between the tributaries and main channel. A pattern of this type is termed *trellis* (Fig. 7-16).

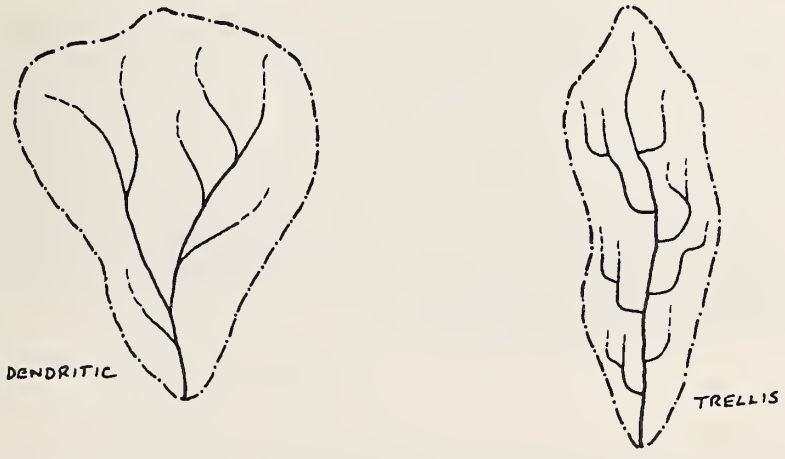

Fig. 7-16. Types of drainage network

Quantitative measures of stream channel development include *stream order* and *drainage density*. Stream order is a useful and simple method for classifying drainage basins according to size. The concept was introduced by Horton (1945) and simplified by Strahler (1952). In this scheme the smallest tributaries are designed as *first-order* streams. When two first-order streams join, they form a *second-order* stream. The junction of two second-order streams results in the formation of a *third-order* stream, and so forth (Fig. 7-17).

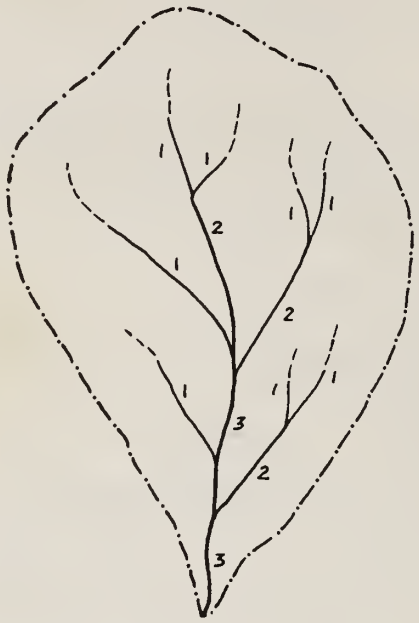

Fig. 7-17. Identification of stream order

Drainage density is defined as the length of stream channel per unit of drainage area, and is usually expressed as km per km^2. It may be calculated from the following equation:

$$\text{Drainage density} = \frac{\Sigma L_c}{A} \tag{4}$$

where ΣL_c = total length of channel in the basin;
A = basin area.

A useful and inexpensive instrument for measuring the channel length on a map is the *chartometer*.[1] Because stream order and drainage density are dependent on the scale of map used, the calculations should always be referenced to the map scale.

Drainage density is a topographic characteristic of fundamental importance in drainage basin studies because it provides a link between the form characteristics of the basin (area, slope, shape, etc.) and the processes operating in it. The drainage density reflects the topographic, geologic and vegetational controls, as well as the influence of man. In general, low values of drainage density are associated with basins containing highly permeable surface materials, dense vegetation cover and low relief. High drainage densities develop in areas of low permeability, sparse vegetation, and high relief.

[1]Chartometers can be obtained from drafting supply storers.

7.3.5 GEOLOGICAL CHARACTERISTICS

The geological characteristics of a drainage basin influence the way in which water passes through it. Of interest are the nature of rock and loose sediment, as opposed to the characteristics of the soil that is developed from these geologic materials through the processes of mechanical and chemical disintegration (weathering). A map showing the distribution of rock and sediment in the basin can give useful insight into the way in which local geology influences surface runoff, groundwater movement, drainage network development, slope stability, and soil development.

There are two main classes of geological materials - consolidated and unconsolidated. *Consolidated materials* are those in which the component minerals or mineral grains occur as fused or cemented masses, commonly referred to as *rock*. There are three main categories of rock - igneous, sedimentary and metamorphic.

Igneous rocks formed from a molten state, either on eruption as lavas at the surface, or by slow cooling deep within the earth's crust. The commonest kind of lava is *basalt* which is a black, fine grained (composed of small crystals), and hard material. *Granite* is a common example of an igneous rock that formed by slow cooling. It is typically reddish in colour and composed of large crystals (coarse grained).

Sedimentary rocks formed from sands, silts, clays and other materials that resulted from the disintegration of other rocks by the weathering action of the atmosphere, rivers, glaciers and the sea. *Sandstones, mudstones* and *shales* are examples of this type. Some sedimentary rocks are commonly deposited in layers, the thickness of which depends on the uniformity of the depositional processes.

Metamorphic rocks formed from the transformation of igneous and sedimentary rocks under conditions of intense heat and pressure created by burial at depth in the earth's crust. A typical example is *gneiss* which is similar to granite but with minerals deposited in distinct bands or flow lines. *Marble* is the metamorphosed equivalent of limestone.

Unconsolidated materials are those composed of loose or weakly bonded aggregates of sand, gravel, silt and clay. Sediments of this type were deposited by the glaciers that covered much of Canada 15,000 years ago. Today, sands are being deposited by rivers and by the wind. Silts and clays, after being transported by rivers, are being deposited in lakes.

The ease with which water can pass through geologic materials is termed the *permeability*. Permeability depends on several factors - *particle size, sorting, degree of consolidation* and *extent of fracturing*. A commonly used scale for describing particle size is shown in Table 7-3. Sorting refers to the distribution of particle sizes in a sediment. In a perfectly sorted sediment all particles would be the same size. A poorly sorted sediment would contain a variety of particle sizes. The degree of consolidation depends on the extent to which the pore spaces between the mineral grains composing the sediment are filled with cement. Because cementation in many sandstones occurs mainly at the contact points between grains, leaving the pore spaces clear, their permeabilities can be high. Table 7-4 shows the relative permeabilities of some common geologic materials.

Table 7-3. Scale of particle size

Description	Size (mm)
Gravel	> 2.00
Sand	≥ 0.063 but < 2.00
Silt	≥ 0.002 but < 0.063
Clay	< 0.002

Channel networks are best developed in drainage basins underlain by geologic materials of low to moderate permeabilities where surface runoff and erosion are high. In basins where permeabilities are high, precipitation is readily absorbed, and channel development is poor.

Table 7-4. Relative permeabilities of common geologic materials

Description	Permeability	Comment
Gravel	High	
Sand	Moderate to high	
Silt	Low to moderate	
Clay	Low	
Sandstone	Low to moderate	Depending on porosity
Limestones	Low to moderate	Depending on porosity
Shale	Very low	

7.3.6 THE STREAM CHANNEL

As previously noted, streams receive water from two primary sources, surface runoff and groundwater. Although direct measurement of these sources is beyond the scope of the field naturalist, we will consider indirect ways of assessing their relative contributions.

Careful observations of the physical characteristics of the stream channel can yield useful data on the discharge of water and the nature of sediment movement in the drainage basin. A useful first step is to carry out a field study of the stream bank, flood plain and channel (Fig. 7-18). Observations should include the nature of the bank material, whether it be consolidated or unconsolidated, presence and type of vegetation that may have a stabilizing influence on the banks, and steepness of the stream bank. Floodplain observations should include extent, surface characteristics such as areas of temporary or permanent marsh, type of vegetation, and presence of abandoned channels.

Fig. 7-18. Components of a valley cross-section

The form of the channel in a particular part of the drainage basin can be classified as braided, meandering or straight, depending on the influence of topographic and geologic constraints (Fig. 7-19). In unconsolidated sediments the most efficient way of conveying water through a drainage basin is through a slightly meandering channel. The meandering channel is the rule rather than the exception. If the channel is noticeably straight, the assumption can generally be made that its position is being controlled by local geology such as a fault line and jointing or by man-made influences such as retaining walls and gabion baskets.

Braided streams are typically wide and shallow and flow occurs through a number of interconnecting channels separated by islands on bars. The channel as a whole does not meander, but meandering does occur in the minor channels between the islands as a result of local erosion.

Observations along the length of a channel will usually reveal a sequence of pools and rapids spaced at fairly regular intervals. In meandering channels the pools occur at the bends and the rapids between the bends (Fig. 7-20). The pools in straight parts of a channel generally have a semi-circular cross-section, while in meandering sections the cross-section is asymmetrical (Fig. 7-20). In the latter, the channel slopes from the inside of the bend (point bar) towards the outside of

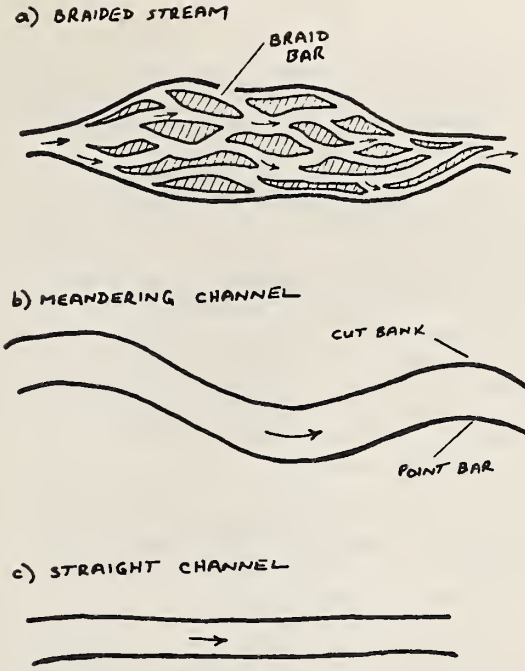

Fig. 7-19. Channel patterns - braided, meandering and straight

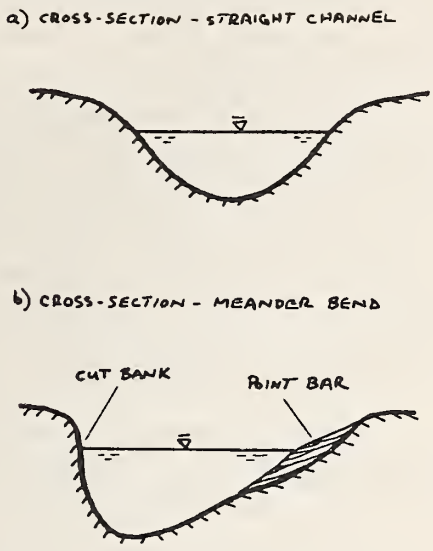

Fig. 7-20. Types of channel cross-section

the bend (pool). Because flow in a meandering channel is directed towards the outside of the bend, erosion of the bank takes place at this point (the cut bank). The coarser sediment eroded from the cut bank is deposited on the next point bar downstream. The finer sediment becomes part of the *suspended load* of the stream and may be carried out of the drainage basin. It is worth noting that erosion of sediment from the stream banks is the primary source for suspended load in drainage basins that have not been unduly affected by the activities of humans.

An overview of the gradients along a stream channel can be obtained by plotting the longitudinal profile of the stream. This can be done by plotting the elevation of various points along a stream channel against their distance from the mouth on a piece of graph paper (Fig. 7-21). The necessary information can be obtained directly from topographical maps.

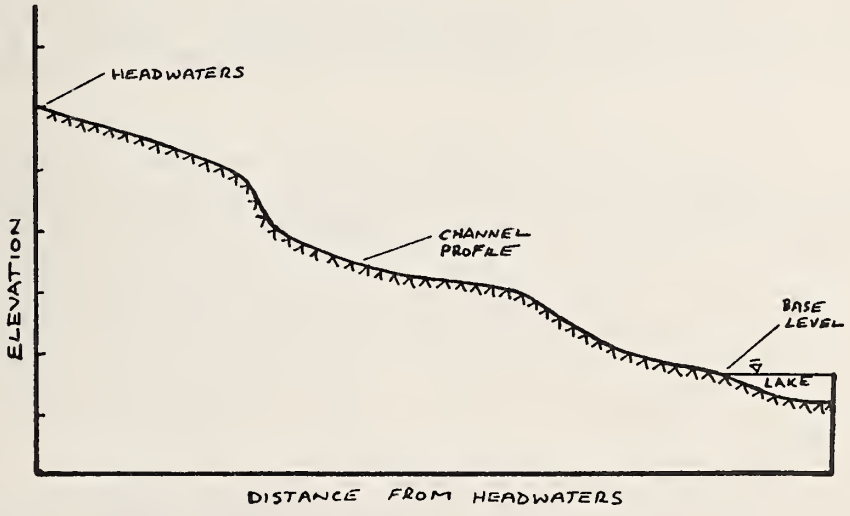

Fig. 7-21. Longitudinal profile of a stream

7.3.7 MEASUREMENT OF STREAMFLOW

Streamflow discharge is the volume of water passing a given point on a stream in a given time. It is commonly expressed in cubic feet per second (cfs) or cubic meters per second (cumecs). The water level at a particular location on a stream is called the "stage".

Discharge data are collected in Canada by the Inland Waters Directorate for selected drainage basins.[2] For some of the streams the records date back to the early 1900's. On small basins (less than 250 km^2 in area) data are usually collected near the mouth, but for the larger ones, measurements are collected at several points. The Water Resources Branch of the Ontario Ministry of the Environment[3] collects streamflow data on a periodic basis for some of the smaller drainage basins, particularly in agricultural areas. Very little hydrologic data are currently available for urban areas in Canada and this fact has hampered studies by various municipalities into the effects of urbanization on water and sediment discharges in their areas. Furthermore, the chance of finding published hydrologic data for ravines and small basins in urban areas is almost non-existent.

Although a detailed discussion of methods for determining streamflow discharge is beyond the scope of this book, there are some measurements and techniques that can be carried out with limited resources and background. These will allow an educated estimate of discharge to be made on ungauged drainage basins.

In order to determine discharge at a particular point on a stream, it is necessary to know the cross-sectional area of the channel containing water and the streamflow velocity. In a rectangular channel the area of cross-section can be determined by a simple measurement of the width and depth of water (Fig. 7-22). Unfortunately very few natural channels are rectangular. Instead, they tend to be irregular, with the deepest water tending to be near the centre of the channel.

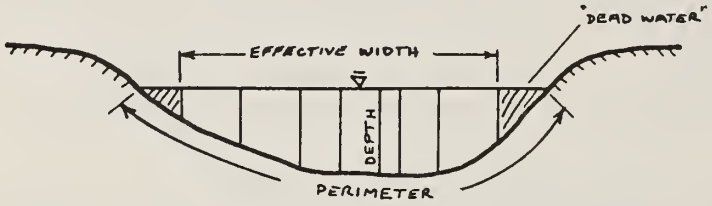

Fig. 7-22. Definition of channel cross-section variables

An average depth of water in a channel cross-section can be determined by taking several measurements with a metre stick and averaging them. The channel width should be measured between the *first* and *last* measurement of depth (Fig. 7-22). The cross-sectional area of the channel can be determined from the relationship:

$$\text{Area} = \text{mean depth} \times \text{width} \qquad (5)$$

In modern stream gauging practice *flow velocity* is measured with a current meter which is a propeller or cup device that turns at a rate proportinal to the flow velocity (Fig. 7-23). The relationship between flow velocity and turning rate is established in the laboratory.

If a current meter is unavailable, an estimate of velocity can be obtained from the Manning equation which states that:

$$v = \frac{R^{2/3} S^{1/2}}{n} \qquad (6)$$

[2] Inland Waters Directorate, Water Resources Branch, Environment Canada, Ottawa, Canada.
[3] Ontario Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario

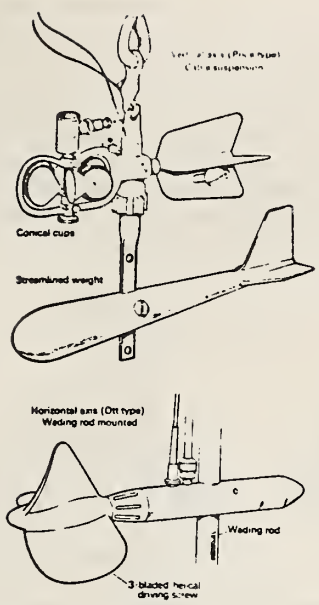

Fig. 7-23. Standard types of current meter

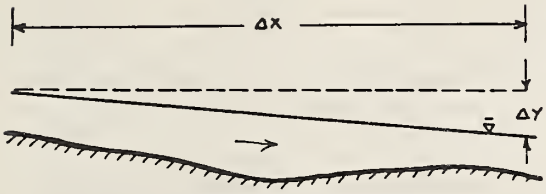

Fig. 7-24. Determination of channel slope

where v = velocity in metres per second;
R = hydraulic radius in metres;
S = slope of channel;
n = channel roughness.

Hydraulic radius is defined as the cross-sectional area of the channel divided by the perimeter (Fig. 7-22). Perimeter can be measured by laying a tape across the channel bottom from one side to the other. For practical purposes the mean depth of the stream can be used in place of hydraulic radius. Measurement of slope can be made with a *surveyor's level* or *hand level*. Slope is simply the difference in elevation between two points along the section of stream channel of interest divided by the horizontal distance between the two points (Eq. 3). For practical purposes the distance can be measured directly along the bank of the channel and should be about 30 times the channel width at the measuring point (Fig. 7-24).

The channel roughness, n, is a measure of the resistance to flow created by the banks and the bottom. Basically the smoother the channel boundary, the lower the resistance to flow. Table 7-5 lists some representative values for various types of channel roughness.

After the cross-sectional area of the channel and the flow velocity are known, the discharge rate can be calculated from the equation:

Discharge = Area x Velocity (7)

The Manning equation is widely used by civil engineers to estimate discharges from small unmonitored watersheds as part of the design procedure for storm sewers in new subdivision areas. It can also be used to estimate flood flows by making measurements of depth from the streambed to the maximum height of erosion on the stream banks. This can be done by stretching a string across the channel at the height of maximum erosion. Depth measurements are then taken at several points across the channel, using the string as the water surface that would exist during the flood flows.

Table 7-5. Selected values for channel roughness

Channel condition	Channel roughness
Straight, no vegetation, no pools full stage	0.029
As above but with weeds and stones	0.035
Straight no vegetation winding, pools and shallows	0.039
As above at low stage	0.047
Winding, pools and shallows, weeds and stones	0.042
As above, shallow, large stones	0.052
Sluggish, weedy with deep pools	0.065
Very weedy, sluggish	0.112

Note: These are averages from many determinations and may vary as much as 20%. (Source: Linsley *et al.* 1975)

The use of the Manning equation requires that the cross-sectional area of the channel at the gauging point be known. In small shallow streams, such as those that flow through many ravine areas, measurements of depth of flow are difficult to make. In such cases erection of a small V-notch weir may be a way of obtaining discharge readings (Fig. 7-25). For practical purposes, the maximum width of channel should be about four metres. The function of the weir is to provide an opening of known dimensions through which water is forced to flow. Under such conditions, a single measurement of *effective water depth* (head), upstream from the weir, is all that is necessary for the calculation of discharge from the formula:

$$Q = 1.38 \tan \left(\frac{\theta}{2}\right) H^{2.5} \qquad (8)$$

where θ = angle of the V-notch;
H = head in metres;
Q = discharge in cubic metres per second.

The angle of the V-notch should be chosen on the basis of the range of discharges to be expected. Table 7-6 lists the range of discharges for commonly used notch angles.

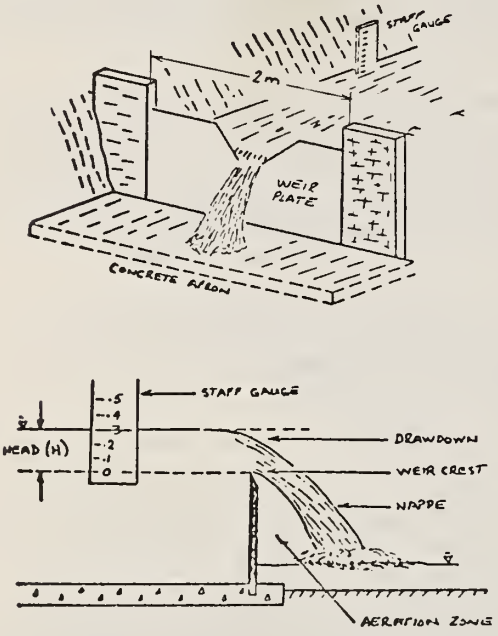

Fig. 7-25. Sharp-crested V-notch weir and components

Table 7-6 Range of discharges for V-notch weirs

Type	Minimum	Maximum
45° V-notch	0.10 l/s	120 l/s
90° V-notch	0.20 l/s	240 l/s
120° V-notch	0.45 l/s	430 l/s

Note: discharges are in litres per second (l/s)

Measurements of head can be made from a mounted water level indicator (staff gauge) positioned such that its base is level with the top of the weir notch. The indicator should be positioned so as not to be influenced by the lowering of the water surface that occurs in the vicinity of the weir (Fig. 7-25).

At permanent flow monitoring stations (gauges), water levels are usually monitored continuously with a float connected to a recorder (Fig. 7-26). The float rises and falls in response to changes in the water level in the stream.

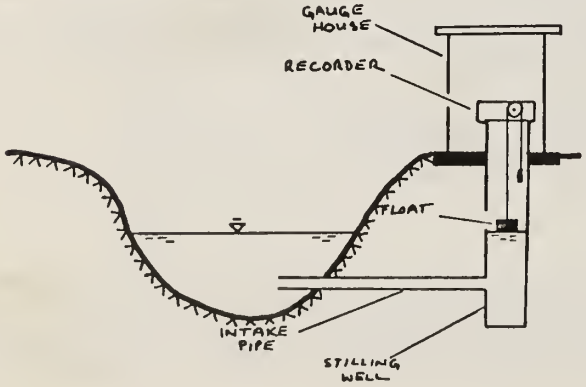

Fig. 7-26. Water level recording gauge

7.3.8 THE HYDROGRAPH

The hydrograph is a graph of stream discharge rate through time. The most common types used by hydrologists are the annual hydrograph and the storm hydrograph.

The *annual hydrograph* is a way of showing the distribution and magnitude of discharge in a stream channel on a yearly basis. It is obtained by plotting the average discharge for each day on 365 day graph paper.[4] In order to gain insight into the relationship between rainfall and streamflow, rainfall data are often plotted on the same graph (Fig. 7-27).

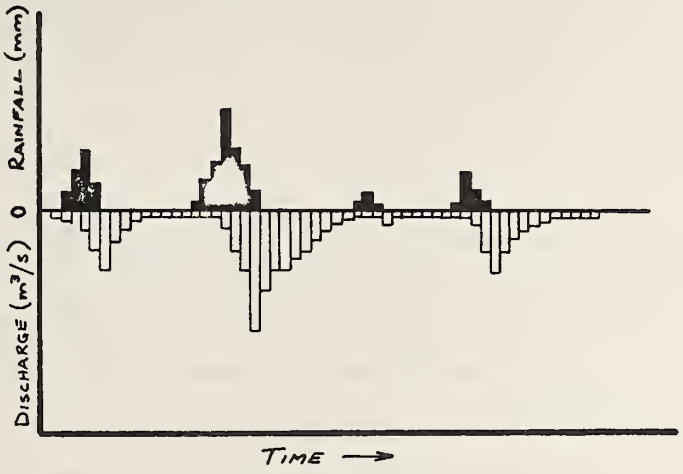

Fig. 7-27 Annual hydrograph/rainfall graph

A more detailed understanding of the relationship between rainfall and streamflow can be obtained by analysing hydrographs for individual storms. The *storm hydrograph* represents the response of the drainage basin to a particular volume and distribution of rainfall and will include water from surface runoff and groundwater (Fig. 7-28).

The sequence of events associated with the development of a storm hydrograph is as follows:

1. Prior to surface runoff reaching the gauging point, the flow in the stream is maintained by groundwater discharge which declines slowly through time (base flow recession).

2. Following the arrival of surface runoff from those parts of the drainage basin closest to the gauge, the discharge in the stream will start to increase (point of rise).

3. As more and more of the basin contributes to surface runoff, the discharge at the gauge will increase at a greater rate (rising limb).

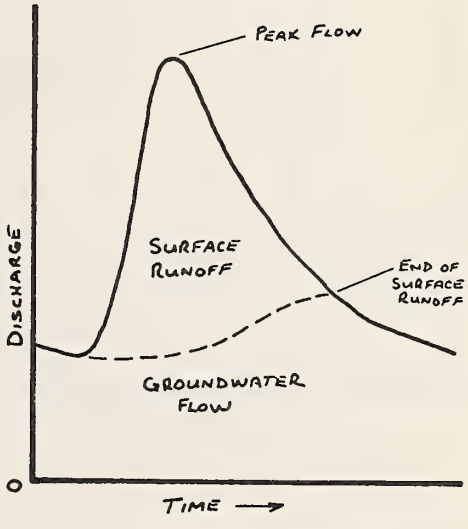

Fig. 7-28 Storm hydrograph components

[4]Keuffel and Esser #47-2810 which is available from most drafting supply stores

4. The hydrograph *peak* occurs when the area of the basin contributing surface runoff is a maximum. The elapsed time between the middle of the storm, and the maximum contribution of surface runoff is termed the *concentration time*.

5. After the peak discharge, the rate at which surface runoff is being supplied to the stream starts to decline (recession limb).

6. Following the end of surface runoff, the streamflow is again maintained by base flow.

Note: Replenishment of groundwater reserves in a drainage basin occurs as a result of rainfall infiltrating the ground and percolating to the water table. As the water table rises during a storm, the discharge of groundwater to streams in the basin will increase, but at a lesser rate than surface runoff (see base flow separation line in Fig. 7-28).

7.3.9 URBAN HYDROLOGY

Of considerable current interest are the possible effects that urbanization will have on the hydrologic characteristics of a drainage basin. Because the streamflow hydrograph represents the cumulative influence of the physical characteristics of the watershed, it can be a useful device for detecting changes in hydrologic response. In general, urbanization of a drainage basin leads to increased volumes of surface runoff. This results from an increase in the area of impermeable surface, roads, rooftops, etc. In many new suburban developments water is conducted from rooftops directly into storm drain systems, where it is conveyed rapidly to neighbouring stream channels.[5]

The effect of more rapid transport of water to the stream channels is twofold. First, the concentration time for surface runoff will be reduced and second, the peak flow will be higher (Fig. 7-29). These responses increase the possibility of flooding downstream and often necessitate engineering modifications to the channel to reduce this hazard. These modifications may range from the stabilization of the channel by grass or gabions to "improving" the channel with concrete and energy dissipators.

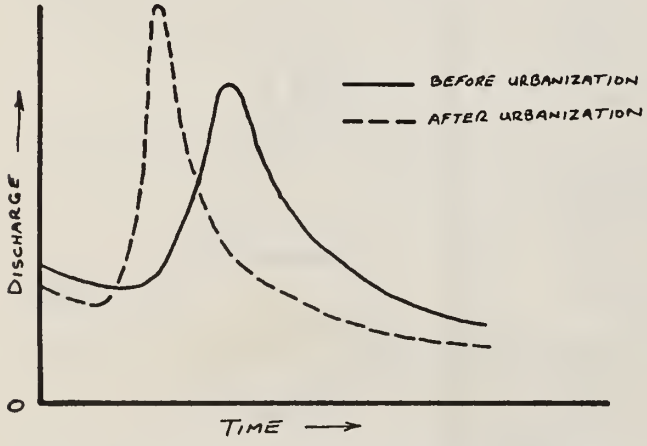

Fig. 7-29. Effect of urbanization on hydrograph shape

The lowering of groundwater levels, through decreased infiltration, in urban areas will ultimately be reflected in lower base flows (Fig. 7-29).

During the land-servicing phase of subdivision development, the vegetation and top soil are stripped from the ground surface. The surface may be left bare for a year or more, and in this condition, it is very susceptible to erosion by rain impact and surface runoff. Runoff flowing rapidly over the surface picks up sediment which is dumped in nearby stream channels. The increased sediment load in the streams results in degradation of water quality (see section 7.3.11) and subsequent destruction of aquatic habitat. Sediment concentrations in streams draining recent subdivisions in the Erin Mills area of Mississauga, Ontario were three to five times greater than in the neighbouring Credit River.

[5]See: Ontario Ministry of the Environment, 1977. Manual of practice on urban drainage (draft), Pollution Control Branch, Toronto.

Recently, the Subcommittee involved with the Canada-Ontario Agreement on Great Lakes Water Quality published an excellent summary of urban drainage management principles and procedures.[6] This document details measures that developers and municipalities can use for maintaining natural drainage characteristics in private developments and public works projects.

7.3.10 FLOOD FREQUENCY

Flooding occurs when the peak discharge in a stream channel cannot be contained within the banks and spills over onto the adjacent floodplain (Fig. 7-18). Under such conditions, the floodplain is an integral part of the stream system. In the past, floodplains have been used for a variety of agricultural, residential and recreational purposes, sometimes with disastrous consequences. Any planned use of floodplains, therefore, should include careful study of the flow characteristics of the river in question. Flows in excess of bankfull discharge are a normal and expected characteristic of rivers. Studies in the eastern part of the United States have indicated that the bankfull discharge will be exceeded once every 1.5 years.

The frequency or recurrence interval of a discharge of a particular magnitude can be determined in the following way:

1. Tabulate the highest discharge in each year of record (annual peak flow).

2. Rank the discharge in order of their magnitude.

3. Determine the recurrence interval for each peak discharge from the formula:

$$\text{Recurrence interval (yr)} = \frac{N+1}{M} \qquad (9)$$

where N = the number of years of record;
M = the rank of the individual annual peak flow.

4. Plot the annual peak flows against the recurrence interval on log-log graph paper (Fig. 7-30).

As an example, consider the annual peak flows for the Credit River at Erindale for the period 1951-1965 (Table 7-7).

Sample Calculation:

For the year 1962, M = 3 and N + 1 = 16

Therefore, the recurrence interval $= \frac{16}{3} = 5.3$ yr.

Besides giving information about the recurrence interval of floods of given magnitude, Fig. 7-30 can be used to estimate the bankfull discharge at the gauging site. As noted earlier, the recurrence interval for flows exceeding the bankfull discharge is about 1.5 years. By entering this value in Fig. 7-30, the bankfull discharge can be estimated. It is important to note, however, that the recurrence interval of 1.5 years is an average obtained from observations on many streams. Consequently the discharge associated with bankfull discharge on a particular stream may be higher or lower than the value obtained from the graph.

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[6] Copies of this publication can be obtained from the Canada Department of the Environment, Water Pollution Control Directorate, Ottawa, Ontario K1A 0H3

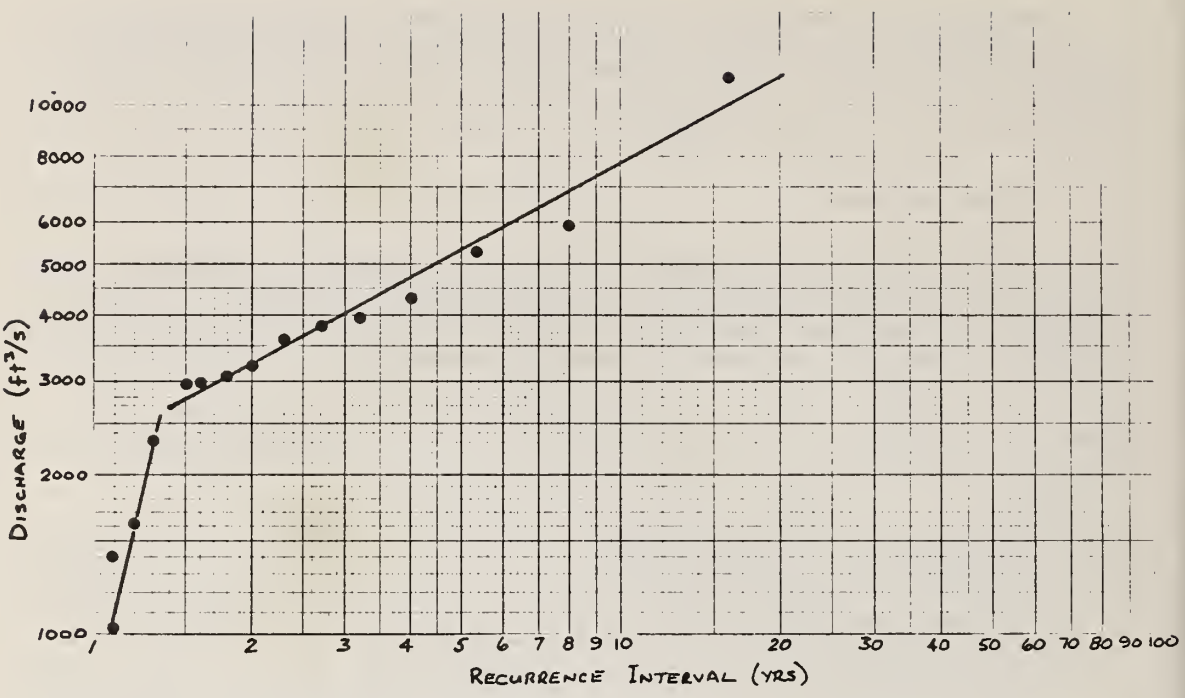

Fig. 7-30. Recurrence interval for annual peak flow

Table 7-7. Recurrence interval for annual peak flow on the Credit River at Erindale 1951-1965

Year	Discharge (ft^3/s)	Rank	Recurrence interval (yr)
1951	3,790	6	2.7
1952	3,990	10	1.6
1953	1,390	14	1.1
1954	11,200	1	16.0
1955	3,620	7	2.3
1956	4,320	4	4.0
1957	3,200	8	2.0
1958	998	15	1.1
1959	3,090	9	1.8
1960	5,920	2	8.0
1961	1,630	13	1.2
1962	5,260	3	5.3
1963	2,990	11	1.5
1964	2,300	12	1.3
1965	3,920	5	3.2

Source: Inland Waters Directorate (1972)

7.3.11 WATER QUALITY

Water is never found in a pure state in nature. It always contains some impurities in the form of dissolved chemicals and insoluble substances. Even water that is distilled during the process of evaporation will pick up impurities such as carbon dioxide during its circulation in the hydrologic cycle. Although water has erroneously been called the "universal solvent", it does have a remarkable ability to dissolve a wide range of inorganic and organic substances. This attribute, together with its ability to render otherwise toxic substances harmless by dilution and bacterial action, has made water an "attractive" transport medium for waste products of human activity. Unfortunately, humans have too infrequently failed to realize that a given supply of water has a limited cleansing capability. Once that limit is exceeded, the water becomes unfit for many domestic, recreational and industrial uses, and is said to be polluted. Although a detailed discussion of the chemistry of natural waters is beyond the scope of this book, the importance of water in the natural environment requires a brief review of its basic characteristics.

The *quality* of water is determined on the basis of its content of substances from the natural environment and waste products associated with human activities. Dissolved substances commonly found in natural waters include compounds of calcium, magnesium, potassium, iron, manganese, sodium and silicon. They occur as carbonates,

sulphates, chlorides, fluorides, nitrates and phosphates. Organic acids associated with the decay of plant matter are also found in low concentrations. Other properties that determine the quality of water result from the chemical and biological processes that take place in the water. These are *colour*, *taste* and *odour*. *Turbidity* in water results from suspended mineral and organic matter and has the effect of reducing the depth of light penetration.

The concentrations of dissolved and suspended substances are usually expressed in milligrams of substances per litre of water (mg/l), or the commonly used equivalent, parts per million (ppm). The new SI unit is micrograms per gram (µg/g). Table 7-8 indicates the 1971 World Health Organization (WHO) International Standards for substances and characteristics affecting the acceptability of water for domestic use. Current (1978) Ontario Ministry of the Environment objectives for municipal water supplies are given in Table 7-9.

Table 7-8. World Health Organization 1971 International Standards for domestic water supplies

Substance or characteristic	Maximum desirable level	Maximum permissible level
Colour	5 Hazen units	50 Hazen units
Odour	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable
Turbidity	5 Formazin units	25 Formazin units
Total dissolved solids	500 mg/l	1,500 mg/l
pH range	7.0 to 8.5	6.5 to 9.2
Anionic detergents	0.2 mg/l	1.0 mg/l
Mineral oil	0.01 mg/l	0.30 mg/l
Phenols	0.001 mg/l	0.002 mg/l
Total hardness	100 mg/l as $CaCO_3$	500 mg/l as $CaCO_3$
Calcium (as Ca)	75 mg/l	200 mg/l
Chloride (as Cl)	200 mg/l	600 mg/l
Copper (as Cu)	0.05 mg/l	1.5 mg/l
Fluoride (as F)	0.9 mg/l at 10°C	1.7 mg/l at 10°C
Iron (as Fe)	0.1 mg/l	1.0 mg/l
Magnesium (as Mg)	30 mg/l	150 mg/l
Manganese (as Mn)	0.05 mg/l	0.5 mg/l
Nitrate (as NO_3)	-	45 mg/l
Sulphate (as SO_4)	200 mg/l	400 mg/l
Zinc (as Zn)	5.0 mg/l	15 mg/l

In natural fresh water, certain undesirable properties may exist even though the concentrations of dissolved solids rarely reach levels that are toxic to humans. For example, carbonates and sulphates contribute to a property called *hardness*. When the concentration of these substances exceeds 200 mg/l, a flaky deposit known as scale can cause problems in kettles and boilers. Iron concentrations in excess of 0.3 mg/l will impart a pinkish colour to the water and cause staining of washing facilities and clothing. In both cases, concentrations at these levels do not pose a danger to health.

Chloride concentration in most natural waters is usually less than 50 mg/l. During the winter, however, concentrations of chloride in excess of this may be detected in streams near snow dumping sites and storm sewer outfalls. The long-term effects of these practices on stream ecosystems is being studies by a group at the Institute for Environmental Studies at the University of Toronto.[7]

The concentration of nitrates (as NO_3) and phosphates (as PO_4) in natural waters are usually less than 2.5 mg/l and 0.1 mg/l, respectively. Prolific algae growth in a stream during the summer is usually indicative that these levels have

[7]Contact Professor P.H. Jones for details.

Table 7-9. Ontario Ministry of the Environment - Drinking water objectives (1978)

Substance	Concentration mg/l
Alkyl benzene sulfonate (ABS) - Anionic detergents	0.5
Arsenic (as As)	0.01
Chloride (as Cl)	250.0
Copper (as Cu)	1.0
Carbon chloroform extract (CCE) - Oil and grease	0.2
Cyanide (as CN)	0.01
Fluoride (as F)	1.2*
Iron (as Fe)	0.3
Manganese (as Mn)	0.05
Nitrate (as N)	10.0**
Phenols	0.001
Sulphate (as SO_4)	250.0
Total dissolved solids (TDS)	500.0
Zinc (as Zn)	5.0
Total Organic Carbon (as C)	5.0
Organic Nitrogen (as N) - Total Kjeldahl Nitrogen minus Free Ammonia	0.15
Methane (Groundwaters only)	50 cu.ft/100,000 gal

*When fluoride occurs naturally in drinking water, the concentration should not exceed 1.2 mg/l. A concentration greater than 2.4 mg/l constitutes grounds for rejection of the supply. Where fluoridation of water supplies is practiced, the recommended range of concentration is 0.8 to 1.2 mg/l.

**In areas where the nitrate content of the water supply is known to exceed 10 mg/l (as N), the public should be warned of the potential dangers of using the water for infant feeding. High nitrate concentrations in water can result in infants contracting cyanosis due to methaemoglobinaemia which inhibits the oxygen carrying capability of the blood.

A water supply can be rejected by the Ministry if the following substances are found in excess of the listed concentrations:

Arsenic (as As - 0.05 mg/l); Barium (as Ba - 1.0 mg/l);
Cadmium (as Cd - 0.01 mg/l); Chromium (as Cr^{6+} - 0.05 mg/l);
Cyanide (as CN -0.20 mg/l); Lead (as Pb -0.05 mg/l);
Selenium (as Se - 0.01 mg/l); Silver (as Ag - 0.05 mg/l)

been exceeded. Nitrates enter streams from bacterial decomposition of sewage and in runoff from agricultural land. High phosphate levels are generally attributable to runoff from agricultural areas or to detergents in sewage. The latter problem has been partly solved through legislation that limits the amount of phosphate in detergents.

In ravine areas lush growth of vegetation in the vicinity of seeps or springs is often indicative of improperly functioning of septic tank systems, or excessive application of fertilizers to lawns and gardens. Of perhaps more importance than the excess nitrate and phosphate in situations like this is the possibility that disease-causing bacteria may be present.

Preliminary bacteriological testing of water samples involves the detection of *total coliform* and *fecal coliform (E. coli)* bacteria. Total coliform counts include bacteria commonly associated with fecal matter (human and animal), and soil and vegetation. Fecal coliforms are mainly species associated with human and animal fecal matter and are usually indicative of fairly recent pollution input. At present there are no legal limits for bacteria content of water. The recommended limits for drinking water are available from Health and Welfare Canada in their publication - *Microbiological Quality of Drinking Water.*[8]

[8]Copies may be obtained from Information Services, Health and Welfare Canada, Brooke Claxton Building, Ottawa, Ontario K1A 0L2

Of increasing concern to environmentalists in many areas is the thermal pollution of lakes and streams through the introduction of cooling water by power stations and industry. Because the solubility of dissolved oxygen in water decreases with increasing temperature, and fish require more oxygen at high water temperatures, thermal pollution can result in a decline of desirable species, such as trout, and an increase in more tolerant, but less desirable species, such as carp and sucker.

In recent years, many complex and toxic organic compounds have been detected in natural waters. Reference to substances such as PCB's (polychlorinated biphenyls) DDT (dichlorodiphenyltrichloroethane) and dioxins is regularly made in the press. Their presence has been attributed to indescriminant use and disposal of industrial chemicals, and the application of agricultural chemicals. The analytical procedures for identifying these substances are extremely complex, and can only be carried out by large government, institutional and commercial laboratories. For many of the compounds, the acceptable levels, if any, in water are in the nanogram (10^{-9}g) per litre (ng/l) range. A listing of commonly used pesticides and their ecological hazard may be found in McNeely *et al.* (1979).

7.3.12 THE TESTING OF WATER

Detailed chemical analysis of water samples is beyond the capabilities of most laymen and should be carried out by government or private laboratories. However, portable test kits are available at relatively low cost that provide the opportunity of *detecting* excess levels of dissolved substances or abnormal conditions in the water. Kits of this type are available from the Hach Chemical Company[9] and BDH Canada Limited.[10]

Routine tests that can be carried out at very little expense are *temperature*, *pH*, *colour* and *odour*.

Field measurements of temperature are best carried out with an armoured thermometer in order to minimize breakage, and should be read to the nearest degree Celsius. The pH is a measure of the acidity of water. If the pH is less than 7.0, the water is acidic. Water with pH greater than 7.0 is considered alkaline (basic). Most natural waters have a pH in the range of 6.5 to 8.5. A pH value outside this range may be indicative of industrial or domestic pollution. Inexpensive equipment for field testing of pH is available from laboratory supply houses.

Most natural waters are slightly yellow in colour. If water is highly coloured, some form of industrial pollution can generally be assumed. If water has an objectionable odour, some form of inorganic or organic pollution should be suspected.

The method of collecting water samples is critical. If the wrong type of bottle is used, or the collection procedure is wrong, the tests may be invalid. Collection procedures and special bottles are available from the Ontario Ministry of the Environment[11] or local Ministries of government or natural resources laboratories in other provinces.

If special bottles are unavailable, the best substitute is a clean glass bottle. Samples for bacteriological analysis must be collected in specially sterilized bottles containing preservatives. When collecting the water sample, the bottle should be fully immersed before removing the cap to avoid contamination by floating material. The cap should be held over the mouth as the bottle is removed from the water.

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[9] Hach Chemical Company, P.O. Box 389, Loveland, Colorado, 80537, U.S.A.
[10] BDH Chemicals, 350 Evans Avenue, Toronto, Ontario M8Z 1R5
[11] Ontario Ministry of the Environment, Laboratory Services Branch, Resources Road, Highway 401 and Islington, Toronto, Ontario

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Horton, R.E. 1945. Erosional development of streams and their drainage basins - hydrophysical approach to quantitative morphology. Geol. Soc. Amer. Bull. 56:275-370.

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Ontario Ministry of the Environment 1977. Manual of practice on urban drainage. (draft), Pollution Control Branch, MOE, Toronto.

Strahler, A.N. 1952. Dynamic basis of geomorphology. Geol. Soc. Amer. Buul., 63:1117-1142.

FURTHER READING

GENERAL HYDROLOGY

Bruce, J.P. and R.H. Clark 1966. Introduction to hydrometeorology. Pergamon Press, London, 319 pp.
- a basic text on methodology for hydrometeorological research with Canadian examples.

Chow, V.T. 1964. Handbook of applied hydrology. McGraw Hill, New York, 1418 pp.
- the standard reference work for all aspects of hydrology.

Gregory, K.J. and D.E. Walling 1973. Drainage basin, form and process. Arnold, London, 456 pp.
- a well illustrated text dealing with the measurement of form and process in the context of the drainage basin.

Linsley, R.K., M.A. Kohler and J.L.H. Paulhus 1975. Hydrology for engineers, 2nd. Edition, McGraw Hill, New York, 482 pp.
- an excellent university level text on basic principles of hydrology. The importance of computer methods is stressed.

Leopold, L.B. 1974. Water - a primer. Freeman, San Francisco, 172 pp.
- a basic introduction to the study of water.

Morisawa, M. 1968. Streams - their dynamics and morphology. McGraw Hill, New York, 175 pp.
- a clear and concise presentation of the fundamental concepts of drainage basin development.

WATER QUALITY

Andrews, W.A. 1972. Environmental pollution. Prentice-Hall Canada, Scarborough, Ontario
- a well presented introduction to the field study of air and water pollution. Contains a well illustrated selection on the collection and field analysis of water samples.

Hem, J.D. 1970. Study and interpretation of the chemical characteristics of natural water, 2nd. Edition. U.S. Geol. Survey Water Supply Paper 1473, U.S. Govern. Printing Off., Washington, D.C., 363 pp.
- an excellent and inexpensive reference on the quality of natural waters.

McNeely, R.N., V.P. Neimanis and L. Dwyer 1979. Water quality sourcebook a guide to water quality parameters. Inland Waters Directorate, Water Quality Branch, Environment Canada, Ottawa, Canada, 88 pp.
- a well presented and readable introduction to the substances that determine the quality of natural water.

Ontario Ministry of the Environment 1978. Water management - goals, policies, objectives and implementation procedures, MOE, Toronto, 65 pp.

UNESCO-World Health Organization 1978. Water quality surveys - a guide to the collection and interpretation of water quality data. Prepared by the IHD-WHO Working Group on Water Quality, Paris, France, 350 pp.
- comprehensive but readable, this publication is one of the best introductions to the collection and analysis of water quality data available today.

DATA SOURCES

Maps - Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa.

Air Photographs - Canada Centre for Remote Sensing, Ottawa; provincial ministries of natural resources; and Kenting Earth Sciences Ltd., Toronto.

CHAPTER 8

SUB-SYSTEM STUDIES: BIOTIC FACTORS

8.1 GENERAL INTRODUCTION

This chapter deals with plants and animals within an area selected for special study, probably a small, restricted and clearly delineated area. In order to establish the need for preserving a habitat, the following are required:

1. a map of the area emphasizing distribution of plant communities and major natural features;

2. an assessment of the plant communities as habitats for vertebrates (amphibians, reptiles, birds, mammals) and, possibly, important invertebrates;

3. a list of plants and animals found in each of the major plant communities identified in step one.

Start by making a rough map of the areas, preferably based on what you know about *soils* (broad categories such as gravel, sand, loam, clay) and *hydrology* (drainage patterns, seasonal variations in moisture at the surface, permanently wet areas such as streams, ponds, lake shore). Indicate the principal natural features and roughly delineate the outlines of the major plant communities. These can be refined as the investigation proceeds.

The result will be a map of the study area subdivided into more or less "natural" units based either on physiographic features (stream bank, flood plain, old field, ravine slopes, etc.) or on mixed vegetation patterns (sedges, rushes, grass-herb, grass-herb-hawthorn, mature hardwood, etc.) or some combination of criteria. In any case the investigators will now come to view the area as a mosaic of "communities", primarily defined by the pattern of vegetation.

Plants and animals can be listed for each community and the most sensitive ones identified on the basis of rarity of species, tendency towards erosion and flooding, and uniqueness of the community itself in the local, regional or national context. The techniques for describing communities in more precise terms are set forth by Maycock in Section 8.2. If some of these methods are used, it will become possible to define community boundaries more precisely and to identify new sub-divisions not noted in the first survey.

Terrestrial creatures can be assessed according to the methods given in the section on wildlife. Habitat preferences, relative abundance and other aspects can be described on the basis of the community map. The same principles govern aquatic environments but they are more difficult to apply.

The result of your study should be:

1. a general *biological* description of the area(s) on the basis of *soils* and *hydrology*;

2. the identification of biologically significant elements worthy of preservation.

In the end you may find that the area has no unique features but requires preserving simply because of the scarcity of green spaces within the urban setting. In any case, the data you collect will help to strengthen your case.

8.2 VEGETATION

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8.2.1 INTRODUCTION

In preparing a comprehensive description and inventory of any natural area, the features of greatest significance are generally those of the plants found growing naturally - the *flora*, and the naturally occurring combinations of these plants - the *vegetation or plant communities*. This statement can be made without apparent reservation, even though it is realized that climate, topography, bedrock, soils, moisture conditions, and other aspects of the area interact to produce ecosystems. It is with this understanding that all of the environmental features of a particular site are integrated and expressed in a fairly specific manner to give rise to a specific flora and to specific plant communities, that such a statement may so readily be put forward. These phenomena, in turn, have great impact on the development of the environment and prepare the conditions for other organisms - dependent plants and animals. The plants and vegetation are also mainly responsible for the landscape features of a region, thus scenic and cultural aspects are also dependent upon them.

It is important at the outset to define carefully *flora* and *vegetation* and to distinguish clearly between them. *Flora is the total list of plants found growing in an area.* Although general statements might be made about representation, a flora implies nothing about abundance of individual species. An attractive rare native orchid is just as important in the floral list as a widespread huge tree. On the other hand, *vegetation studies include not only a list of component species but account for their numerical or quantitative representation.* Vegetation types or forest types are often identified in terms of the abundant larger dominants which contribute the bulk of biomass or living material to the plant cover of a site. Thus in southern Ontario we speak of sugar maple-beech forest. Farther north in the Cochrane area, black spruce-balsam fir forest may be prevalent.

This contribution to the study of natural areas, whatever their location, is concerned with determining, interpreting, and elaborating upon their flora and vegetation.

8.2.2 FLORA

It is impossible for the amateur naturalist or for the majority of competent botanists or plant ecologists to determine the total flora of even a limited area. This may seem discouraging but it is in fact intended to be encouraging. The plants of a site consist of bacteria, protozoans, algae, fungi, mosses, lichens, liverworts, club mosses, ferns, and higher plants, as well as other plant organisms which may attack them or disease them. No botanist today has sufficient experience with all of these organisms to walk into a community and make a list. Just to collect many types or even to observe or find them, requires considerable expertise. Generally, we do not need to inventory all groups and, if we do need to study difficult types, it is possible to obtain assistance.

For the purposes of description of a natural area, the bulk of plant species involved will be those of the higher vascular groups - trees, shrubs and herbs. Often mosses and lichens and fungi may also be important or interesting. These groups are readily recognized and, if of sufficient abundance or frequency, may be collected. Never collect rare species which are represented by only a few individuals. Some of these plants may add great interest to the area but are of little value even for scientific purposes if their populations have been decimated or totally eradicated. Such rare species can be photographed carefully in colour to provide documentation or examples for identification. Plants such as algae, bacteria and protozoans cannot be dealt with except in special circumstances and then only by specialists. The most emphasis should be placed on the higher vascular plants.

There are several approaches to producing an accurate floral list of a defined or bounded area. An experienced naturalist can list a significant percentage, up to 85%, by observation in the field. If you cannot identify species and an assistant is unavailable, then collect and press specimens: twigs with leaves and flowers and/or fruit from trees and shrubs; whole plants or portions, preferably in flower or fruit or herbs; whole pieces for fungi, mosses, lichens, liverworts, etc. These are flattened and dried between newspapers on each of which is clearly written the date and place of collection, vegetation type and environmental description, if possible, and the name of the collector. Instructions for these procedures are clearly presented in "Collection and care of botanical specimens" (Savile 1962).

These collections, when properly cured, can be taken to experts for identification. There are institutions and persons who will assist with this process according to their specialities or abilities or who can help you to find people who will. Important in this regard is that specimens are properly collected, preserved and retained for reference if desired. Repositories for such collections are often found in biology or botany departments at most universities. Major herbaria (collections of dried specimens) are found in Ottawa in government departments (National Herbarium of the National Museums, Plant Research Institute of the Department of Agriculture) and frequently in provincial museums. Addresses for some of these institutions are provided at the end of this Section. Remember that these people are providing a public service but they are taking precious time from research and other pressing practical problems to assist you. If you can obtain the services of a competent naturalist, biology graduate or undergraduate, even to identify many of the common plants and to help you get started, do so. They should be paid for this assistance and be provided with expenses. The institutions may be able to suggest names. If the area includes a marsh, pond, lake or stream, you may require help in deciding what plants to collect and how to proceed.

Your ultimate goal is to produce a list of all of these kinds of plants, but especially the higher plants. Then mosses, lichens and fungi should follow in that sequence, if possible, in order of relationships (taxonomic order) in families, named by genus and species, and followed by the authority who named and described them. You may also include comments on the relative abundance of each. A scale such as abundant, common, frequent, uncommon, and rare is useful.

EXAMPLES

Pinaceae - *Pinus strobus* L. - White Pine. Scattered tree throughout the area.

Gramineae - *Brachyelytrum erectum* (Schreb.) Beauv. Bearded Short-Husk Grass. Uncommon.

Liliaceae - *Clintonia borealis* L. Blue-bead Lily. Uncommon.

Maianthemum canadense Desf. Wild Lily-of-the-valley. Common.

Compositae - *Taraxacum officinale* Weber. Dandelion. Only a few individuals observed. Introduced along paths.

A well organized plant list is a very impressive document to present at a legal hearing, before a planning board or to a group of interested and concerned naturalists or scientists (Catling 1980). It has value for a number of reasons.

1. If properly assembled, it indicates that a careful study has been conducted and that the individuals involved have at least a professional approach if not in fact professional status.

2. It provides an indication of the ecological diversity or variety of the area. The plants are often indicators of specific environmental conditions and the list summarizes this to an extent. It may indicate soil types, moisture conditions, microclimate, stoniness, degree of disturbance, etc.

3. It gives an impression of the kinds of plant communities present, since many species occur in a relatively restricted number of vegetation types. Example - mesic deciduous forest, mixed deciduous-evergreen forest, marshes, fens, and thickets (Maycock 1980).

4. The list indicates not only the species that are abundant or common and generally expected in a region but also the rare and uncommon ones (Argus and White 1977). A trained taxonomist or ecologist could provide an assessment of the interesting or even unique aspects of a flora for the region. Amateur naturalists often turn up interesting plant occurrences or distributions.

5. Among other things it will help provide a basis for assessing the impact that human activities have had on the location. Generally the flora of a natural site has between 15 and 20% of species which have come from alien floras in distant regions. (The exact percentage can be determined from any regional manual such as Gray's Manual of Botany.) If the percentage for your situation is lower, it would indicate that the vegetation is natural and is not seriously disturbed. A higher proportion would indicate the reverse; such a situation might have to be qualified in a presentation.

6. The more complete and accurate the list, the greater impression it will convey to all concerned, especially those with ecological expertise.

8.2.3 VEGETATION

The plant groupings of the area under consideration express in a total way the intricate and interrelated environmental conditions of the site. They are the summation of all ecological factors and the corporate indicators of the environment. They express such features in a qualitative, quantitative, and in a visual way such that they may be considered from a scientific view, or at the opposite end of the scale - from a purely aesthetic or scenic landscape view. Thus a careful study of vegetation can be very revealing of the intricate ecology of an area or can be useful for its inherent aesthetic value. Vegetation also has great practical value concerned with conservation of resources and the environment.

There are many approaches to studying plant communities, but perhaps the most difficult part of the process is to recognize the different types and to be able to decide their limits. The most helpful feature for this purpose is really a simple one - physiognomy or general outward appearance. First train yourself to distinguish between forest, thicket, field, meadow, marsh and floating aquatic communities - as general examples. The next step is to separate deciduous broad-leaved forest from evergreen needle-leaved forest and both from mixed diciduous-evergeen forest. When these phenomena are more closely surveyed, it will become possible to recognize sugar maple-beech-basswood forest; beach-sugar maple-hophornbeam forest or sugar maple-hemlock-white pine-yellow birch forest. These latter communities are evident because they are dominated by a limited number of tree species and the quantitative combinations of these dominants occur over a specific area. There is a limited number of trees which can be the dominants in forest communities in any particular area.

It is of the utmost importance to be able to distinguish community types. Recognition is a first step towards study, mapping, and description. If you cannot recognize, you must obtain the services of a competent ecologist, biologist, or naturalist.

Plant communities must then be documented. Several approaches are possible but the more thorough the study, the greater will be the interpretive possibilities. The approaches are: 1. descriptive; 2. qualitative; and 3. quantitative.

DESCRIPTIVE STUDY

In a descriptive study, the communities are distinguished and then described in a general way taking into account location, extent, topographic situation, soil type, moisture characteristics of the site, slope degree and exposure, existence of rock outcrops, homogeneity of site features throughout, as well as other environmental influences. Vegetational features such as *component layers* - tree, suncanopy tree, sapling reproduction, tall shrub, low shrub, tall, medium or low herb, moss, and lichens, any of which may be a component; *major dominants* - contributors to cover, number, size or biomass in each layer; *condition* - undisturbed by human activities, slightly modified, heavily disturbed, etc., as well as any features which may be specific to the particular community. The latter may include fire, grazing by native or introduced animal populations, periodic flooding or drought, disposition of boulders or erratics, soil erosion, old stumps or dead standing trees, disease of different plants, windthrow, log debris from former windthrow, as well as a host of other specific features. These general environmental or vegetational characteristics are important in interpretation and are talking points in a presentation. Therefore, they should be recorded whether a study is extensive or intensive. The descriptive method is usually employed alone when the time factor is important and only a brief visit and study can be made.

QUALITATIVE STUDY

In a qualitative study the same observations are recorded but much more time is spent in each stand (area of a community selected for examination or study) to obtain data on structure and composition of the vegetation. The most important approach is to obtain a list of all of the plants in each community type - often referred to as a *presence list*. Naturally, some plants will perhaps occur in more than one community but many will occur in a single vegetation type. As simple a procedure as the presence list seems to be, it is nevertheless a specific non-duplicable feature which can be used to characterize and identify any particular plant community. It is something that can be used for comparative purposes and related to other studies which may have been completed by vegetational experts in that vegetation type. Such a comparison, if it could be made, would carry much weight in a presentation.

One of the values of obtaining a presence list is that it permits a very close scrutiny of the whole area. If done energetically and consistently, it will add species to the floral list of the area as a whole because many plants are smaller and easily obscured by other larger plants; it also provides additional opportunities to assess the descriptive features outlined above. The investigator accumulates much additional valuable experience which can be employed in producing a written report or preparing a presentation. If time is available in the course of this survey, which should take several hours in a stand even for an experienced phytosociologist (an ecologist concerned specifically with studies of vegetation), additional environmental information may be obtained - examination of soil layers or horizons, recording of soil pH, aging trees with an increment borer, etc. It also extends the time in the stand for assessing dominance in different community layers and for describing other compositional and structural features.

QUANTITATIVE STUDY

A quantitative survey is much more involved; although more time is required, it is well worth the additional effort in terms of the amount of useful information obtained. There are a number of different quantitative techniques which can be used but they are of two general types - *area methods* and *distance methods*. In the former, samples of known area are laid out at random in the stand and, on the basis of counts or measurements in these quadrats, extrapolations to the stand as a whole are made. Distance methods involve the random positioning of sampling points throughout the stand, about which certain measurements are taken which can then be used to deduce certain features of the stand populations.

The *Quadrat Method* (area method) in a forest stand involves the following procedures. The community is assessed for size and disposition and a rough grid system of intersecting lines at least 15 m apart is laid out randomly (Fig. 8-1). At the intersecting points, a 10x10m quadrat is established. These are easily laid out with two tapes of 10 m length. One side 4 m long is staked out and another at right angles and 3 m in length is measured. Then a 5 m tape is stretched from this outer end of the 4 m line to meet the outer end of the 3 m tape to produce the hypotenuse of the right-angled triangle. The outer sides of this are then used to lay out the first two sides of a 10 m square quadrat. The other sides are easily completed with two 10 m tapes.

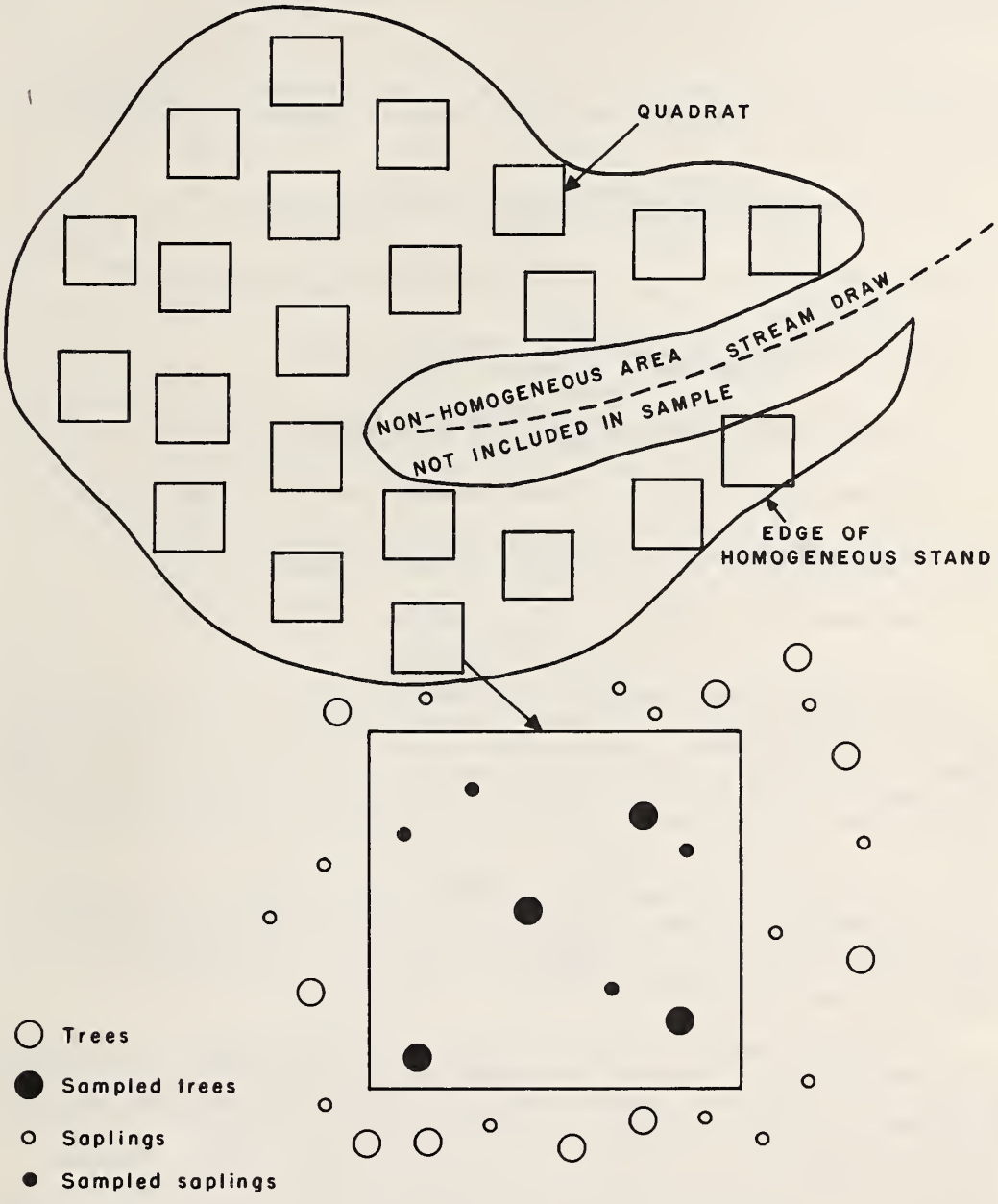

Fig. 8-1. Example of forest sampling quadrat method

Within this quadrat, all trees (woody stems of 10 cm diameter at breast height - 1.4 m above the ground, dbh - diameter at breast height) are tallied on plain paper with ruled columns. The species of each tree is recorded and its basal area and the data for each quadrat are kept separately in each column. Then all saplings (woody stems of potential trees which are at least 2.5 cm diameter and smaller than trees) are tallied in adjacent columns under the appropriate tree species. This is continued for at least ten quadrats; if possible, the data for as many as 20 randomly placed quadrats should be taken. To sample shrubs and herbs, such large quadrats are not required. Metre-square samples are positioned in the larger quadrat at the grid intersection. Then all species of shrubs, tree seedlings (smaller than 2.5 cm diameter) and herbs, regardless of their number, are tallied. In more exacting studies, numbers of plants of each species or their estimated cover could be tallied, but this is not required for an inventory. While this sampling procedure is in progress, a list of all plants present in the stand is accumulated and other observations on environmental features, structural characteristics, and of general ecological interest, are recorded.

The Quadrat Method is not too involved technically but it is quite time consuming; at least two people are needed to lay out the quadrats and assist with the recording. It does produce considerable useful information. The following quantitative indices can be calculated for each tree species:

$$\text{Frequency} = \frac{\text{The number of quadrats of occurrence}}{\text{The total number of quadrats recorded}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of one species}}{\text{Sum of frequencies of all tree species}} \times 100$$

$$\text{Density} = \frac{\text{Total individuals of a species}}{\text{Total area of all quadrats recorded}} \times 100$$

$$\text{Relative density} = \frac{\text{Density of one species}}{\text{Sum of densities of all tree species}} \times 100$$

Dominance = Sum of basal area contributed by the trees of one species

$$\text{Relative dominance} = \frac{\text{Total basal area of a species}}{\text{Sum of basal area for all species}} \times 100$$

Importance value = Sum of relative frequency, relative density, and relative dominance

The *Importance Value* sums to 300 for all of the trees in a forest stand and is a precise indication of the relative importance of any tree species based on three significant measures - *frequency* (distribution from place to place), *density* (number of individuals per unit area) and *dominance* (size or basal area distribution). As an example, if a forest was composed of equal numbers of sugar maple and beech, each would have an importance of 150. Regardless of how strongly represented a species is, it still will have a value proportionate to its influence.

In the metre quadrats used for tree seedlings, shrubs and herbs, frequency (number of quadrats of occurrence as a percentage of all quadrats recorded) is calculated for each species. Thus values are provided for all species in the stand. These can then be used to present a precise statement of composition and to interpret various ecological processes and relationships.

There are a number of different distance methods available but only the most widely used, the *Quarter* or *Point Quarter Method*, is presented here. The stand to be studied is chosen in the same way and uniformity of tree and understorey cover is assessed. A sampling direction is chosen at random; then 25 paces are walked and a sampling point is established where a bisect (crossed sticks) is placed, to divide the forest into four quarters. In each quarter the nearest tree to the point is chosen, its kind or species determined, its distance from the point and its basal area at breast height are both measured. All three features are recorded on a ruled sheet. Then the nearest sapling is chosen and its species and distance

from the point also recorded. The same information is obtained for the closest trees and saplings in order, in the other three quarters, to provide a sample of four trees and four saplings at the point (Fig. 8-2). The amount of canopy cover over each point as a percentage is then assessed. Then another point is paced off in the direction chosen. To measure the ground cover, the presence of all tree seedlings, shrubs and herbs is tabulated in metre-square quadrats at every other point. While walking between points, a careful watch is kept for new species to be added to the list, as well as other observations concerned with environmental characteristics - soil type, ground topography, light distribution, etc., structural features - layers of trees, openings, shrub layers, herb layers, moss layers, etc. and other aspects of ecological interest - animal evidence, natural or human disturbance, rock outcrops, windthrows, tip ups, stumps, local groupings of species, non-homogenous situations, moisture depressions or additional features.

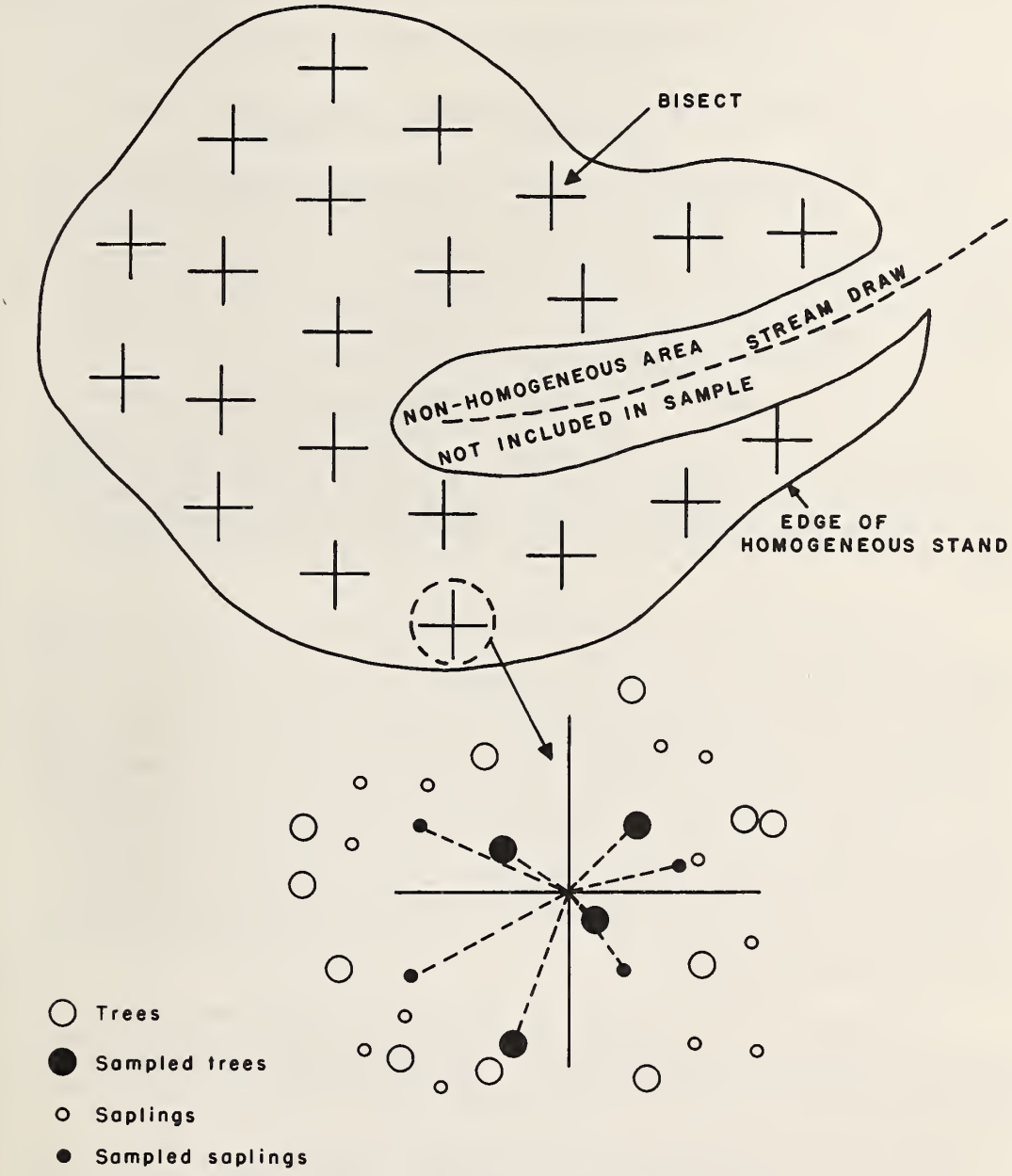

Fig. 8-2. Example of forest sampling point quarter method

This method seems somewhat more involved but is fairly straightforward and it can be conducted by one person. It provides the same type of information but in less time than the *Quadrat Method*. The calculations are as follows:

$$\text{Frequency (Trees)} = \frac{\text{Number of points at which a tree species is found}}{\text{Total number of data points recorded}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a specific tree species}}{\text{Sum of the frequencies of all tree species}} \times 100$$

$$\text{Relative density} = \frac{\text{Number of trees of a specific tree species recorded at points}}{\text{Total number of trees recorded at all points}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Sum of the basal areas for trees of a specific species}}{\text{Sum of basal areas for all tree species}} \times 100$$

Importance value = relative frequency + relative density + relative dominance values for each tree species

$$\text{Frequency (tree seedlings, shrubs and herbs)} = \frac{\text{Number of metre quadrats of occurrence}}{\text{Total number of quadrats recorded}} \times 100$$

Other valuable characteristics may also be calculated from the basic field data which are useful in describing a forest. If all of the point to tree distances are summed, averaged and then the average value squared (multiplied by itself) the resulting numerical value is the average area occupied by a tree in the forest. If this is divided into 10,000 (the number of square metres in a hectare) it yields the number of trees per square metre in that forest. If this is multiplied by the average basal area for all trees sampled, the dominance of basal area per square metre is obtained which is an indication of total productivity.

If the forest community is restricted in size (about 0.5 ha) the Point Quarter Method may still be used, but it will be necessary to run lines of sample fairly close to one another. If the stand is very restricted in extent (less than 0.5 ha) than a more appropriate approach is to distribute 10x10 m quadrats; these may be very close to one another if not adjacent. No stand should be considered too small in a survey because the community is responding to different environmental conditions and provides opportunity for the establishment of other interesting species.

The methods outlined above have dealt with sampling forest communities. What of other vegetation types such as meadows, shrub thickets, cliff vegetation, moist streamside communities, marshes and aquatic sequences? These communities are first identified visually and their extent and limits determined relative to the distribution of the dominant species. Each is carefully walked through and a list of all plants present is slowly accumulated. The occurrence of all species in metre-square quadrats scattered at random on the ground, but covering the extent of the stand, is recorded. Observations on all ecological conditions - moisture characteristics, type of soil, heights of vegetation layers, main dominant species in each layer, flooding, animal activities, influx of tree seedlings, human or other disturbance, stoniness, distribution of erratics, slope, aspects, etc., are also carefully tallied. Frequency values for all plants (percentage of occurrence in total quadrats sampled), may be calculated to provide a quantitative assessment. Percentage cover values for all species in quadrats may be estimated and an average percent cover value determined.

In sampling forests or open communities, soil pits may be examined to determine general soil type, depth of litter and organic layers, depth of developmental horizons, as well as other features. The reaction (acidity, neutrality, alkalinity) of these horizons may be measured by the use of a soil reaction testing kit or pH kit.

References which describe many of these sampling methods are included at the end of this section; a series of data collected in a forest and open community is also provided to show the reader how to record information in the field.

8.2.4 USE OF VEGETATIONAL OR COMMUNITY DATA IN A FORMAL PRESENTATION

No two pieces of vegetation are identical and so uniqueness is an aspect of all natural plant groupings. Nevertheless, it is essential to qualify or even quantify the uniqueness of any environmental situation. Remember as well that any combination of communities can be unusual. Thus the major concern is to describe the group of different plants which occur on a site (flora), to outline the different communities (vegetation), and to illustrate as precisely as possible the composition, structure and environments (sociological features) of these communities. The more precise one can be about these characteristics, the more meaningful and impressive will be the presentation.

Begin with detailed information and end with more general characteristics. Leave scenic, landscape, and conservational aspects until the concluding section. A suggested ordering of important points might be the following, although it may be varied depending on the situation.

1. Reason for interest in the site and its features.

2. Time spent in area - general observations, sampling - all the basis for your knowledge and experience in this environmental situation.

3. Personnel who helped you gain this familiarity and experience - especially where professionals are involved. Include people with whom you corresponded or who identified specimens or assisted in any scientific way.

4. Extent of the area and its individual communities. Does it form a viable whole? Is the ecological situation sufficiently protected for it to endure?

5. List of all higher plants present. In taxonomic order by family, genus, and species, if possible, citing the reference followed, for example, "Gray's Manual of Botany" M.L. Fernald (1950); "100 Shrubs of Ontario" J.H. Soper and M.L. Heimburger (1961).

6. Comment on the number, variety, total native species, introduced weeds (valuable if very low - 17-20% is normal), uncommon species, rare plants, particularly interesting plants - attractive flowers, fruit, foliage, bark useful for animal food or attraction, etc. Consultation with a plant taxonomist can be a great help, but many manuals provide interesting information as can many competent naturalists.

7. Note species of plants at or near the limits of their geographical range.

8. The number of different plant communities present - list forests, then tall thickets, fields, meadows, marshes, aquatic communities, etc. in some logical structural sequence. Comment on any unusual communities - fens, meadows, marshes, unusual forests - bur oak-ash lowland forest, forests including unusual treees - black walnut, hickory, sassafras, hackberry, swamp white oak, sycamore, etc., particularly significant quantities or combinations. This can be very detailed if a vegetational ecologist is consulted.

9. Present detailed data summaries for each community in some logical sequence. This could be accomplished in a well organized table with environmental data included.

10. Unusual structural features - height of layers, density of layers, lack of certain structural elements, complexity of structure.

11. Unusual environmental features - rock outcropping, cliff faces, steep slopes or ravines; wide range of moisture or soil conditions; glacial features with unusual vegetation, abundant erratics (foreign stones or boulders deposited by glaciers - granite in a limestone region); disposition of creeks, streams, particularly headwaters, flushes, draws; apparently rich soil or organic deposits - mucks, peats; high density of animal abodes, rookeries, heronies; heavy litter, dense shade; rough terrain, etc.

12. Interesting seasonal phenomena - spring flora show, extensive fall blooming, beautiful or varied colouration at any period, fruiting of species, variation in any plant features on a seasonal basis or from year to year, different leafing out characteristics for trees in canopy or understorey, etc.

13. Specific and detailed quantitative descriptions for each community in reference to the data collected in sampling, as for example:

    Type of community - generally and specifically - forest types, community type.

    General environmental situation - slope, exposure, flat, bottomland, lowland, upland, etc.

    Interest - typical of the area or region, rare or unusual type, common vegetational community, unique, etc.

    Major dominant or codominants with importance or frequency values or estimated influence.

    Subdominant species with values - percent cover, frequency.

    Other plants contributing significantly to composition or structure.

    Dominants in each of the layers represented may be provided.

    Reproduction - in forests or developing forests, indicating future possible trends in stand development.

    Successional or developmental aspects - if possible, e.g. elm-ash forest with sugar maple understorey; willow thicket being invaded by elm, ash, and silver maple saplings, etc.

    Sizes of major components may be mentioned - particularly large trees, heavy shrub layer, especially tall herbs in ground layer.

14. Descriptions of successive vegetational layers.

15. Unusual or typical environmental characteristics - somewhat open canopy, deep shade, high moisture content of soil, excessive dryness, silt or drift accumulation, etc.

16. Interesting species present - southern, northern, prairie elements, coastal plain species, group of species of same genus or family, etc.

17. Comment on floristic diversity of tree, shrubs, herb, and moss layers.

18. Features produced by unusual environmental influences - heavy shade, overhanging cliffs, outcroppings or intense stoniness, open conditions, soil slip on steep slopes, flushes, animal activities, recreational degradation, etc.

19. Influence of humans or lack of it - logging, stumps, sugaring, grazing, fencing, burning, dumping, etc. Provide estimate of recovery time.

20. Rare or unique species need not always be present to make a community of ecological interest. The habitat features may be unusual, the community may be of particular interest, structural characteristics may be of value. Size or extent, successional aspects or maturity, may all contribute to the intrinsic value of a community. Then scenic, aesthetic, teaching, and recreational aspects may consistently be of value.

21. Aesthetic values - beauty - reasons, landscape or scenic values, erosion control, wildlife habitat, watershed protection, educational use or value, recreational value, nature preservation value, gene pool, etc. Attempt to provide an estimate of time use, e.g. 30 persons @ 2 h each a day for educational visits (each worth the cost of at least a movie!). If a protection battle is being waged, attempt to comment judiciously upon the

effects that an anticipated treatment will have on the plant community and the environment, e.g. - sewage sludge disposal site in the middle of a lowland forest - wastes will pass quickly into the surrounding community at periods of high water level, heavy metal accumulation, etc. Mention any plants which would be eradicated by a specific effect such as selective logging, trampling, partial grazing, or putting a road through a forest complex.

22. Final value assessment and recommendation.

8.2.5 FOREST EXAMPLE: DECIDUOUS-EVERGREEN FOREST - see Appendix I. (PART OF ERINDALE COLLEGE RESEARCH FOREST)

- Fine example of older deciduous-evergreen forest on clay soil typical of the Credit River uplands and of the southern limit of mixed forests in Ontario.

- Red oak is a major dominant (Importance Value - 84 of a possible 300) and sugar maple (66) and beech (52) are significant codominants. Other important trees include red maple (40) - an interesting dominant on an upland site in this region - and paper birch (33). Six other trees have importance values less than 10 - yellow birch (7), white pine (6), white ash (6), black cherry (4), hemlock (2) and white oak (1). The coniferous element is thus minor.

- Most of the reproduction (saplings) is sugar maple and beech, indicating that if present trends continue, oak will be much less important in the future.

- A number of large trees are present, exceeding 1300 cm^2 BABH, and most are red oak. Sugar maples and beech tend to be of small size.

- The tree layer casts a dense shade and this is reflected in a sparse shrub and herb layer.

- In the understorey 12 different species of shrub were present but as scattered individuals. Herbs were represented by 39 species but of these the only one to be found in more than one quadrat was *Maianthemum canadense*. A rich assortment of *Carex* was present, actually 6 species. Four types of woody vines included *Vitis riparia, Celastrus scandens, Solanum dulcamara* and *Lonicera dioica*. A number of pairs of species in the same genus added to the floristic diversity, actually 65 species, which is somewhat above average for this type of forest.

- A number of southern elements are found here - *Hamamelis virginiana, Carex convoluta* and *Podophyllum peltatum*.

- In terms of composition and structural features the forest is not unusual. It does represent a fine example of older forest typical of this environmental situation in the region. It has great value for erosion control along the upper edge of the steep easily eroded clay banks of the Credit River. This value is enhanced by the contribution made to landscape features of this scenic river valley and the limited use that can be made of the forest for wildlife habitats and nature appreciation. As a part of the research and teaching forest complex of Erindale College, University of Toronto, the community has inestimable value and should be preserved intact in perpetuity.

8.2.6 MARSH EXAMPLE: BURR REED-CATTAIL MARSH ON THE LOWER CREDIT RIVER NEAR ITS MOUTH - see Appendix II

- Particularly fine example of a marsh community which forms a segment of a more extensive wetland complex which has become established on clay silt flood plains in the central sections of the Credit River toward its point of outflow into Lake Ontario.

- Regularly flooded, especially at spring runoff, and permanently saturated.

- Dominated by *Sparganium eurycarpum* which attains a frequency in quadrats of 95%. *Typha latifolia* (40) is the only other species contributing significantly to the biomass.

- Other plants forming a more sparse lower layer include *Urtica procera* (20). *Rorippa islandica* (25) and *Polygonum coccineum* (10). *Lemna minor* (70) forms a fairly thick floating mat on the water surface.

- The community includes only 12 species of vascular plants but of these *Carex lacustris* and *Epilobium coloratum* are not common and communities dominated by burr reed of this extent, 1 ha, are not a prominent feature in southern Ontario.

- This community forms a valuable addition to this unusually extensive wetland complex. Such marsh situations are becoming increasingly uncommon in southern Ontario and rare along the Lake Ontario shore between Hamilton and Toronto. The scenic, landscape and recreational values of this marsh are high. As prime habitat for wildfowl and wading birds (great blue heron and bitterns were observed), it is second to none in the region.

- Steps should be taken immediately to make absolutely certain that this entire wetland system is given total protection. The other marshes and meadows form a remarkably fine sequence for teaching the ecology of wetlands.

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Hosie, R.C. 1973. Native trees of Canada. 7th Edition. Can. Forestry Serv., Dept. Environ., Ottawa, 380 pp. Descriptions and distributional maps for native trees.

Maycock, P.F. 1963. The phytosociology of the deciduous forests of extreme southern Ontario. Can. J. Botany, 41:379-438. Quantitative analysis of the deciduous forests of this southern region. Ecology of individual tree species.

Scoggan, H.J. 1966. The flora of Canada. Canada Year Book 1965-1966, Queen's Printer, Ottawa, 27 pp. Presents lists of important plants in different regions. Has many important references pertaining to flora.

Scoggan, H.J. 1978. The flora of Canada. National Museums of Canada. 4 Parts. A new survey of the flora of Canada. The introductory section (Part 1) is useful for general purposes.

USEFUL ADDRESSES OF PROFESSIONAL AGENCIES

National Herbarium of Canada,
National Museum of Natural Sciences,
Botany Division,
Ottawa, Ontario K1A 0M8

Biosystematics Research Institute,
Research Branch, Agriculture Canada,
Ottawa, Ontario K1A 0C6

Park Planning Branch,
Ministry of Natural Resources,
Room 3316, Whitney Block,
Parliament Buildings,
Queen's Park,
Toronto, Ontario M7A 1W3

Herbarium,
Department of Botany,
University of Toronto,
Toronto, Ontario M5S 1A1

Herbarium,
Department of Botany,
University of Toronto,
Erindale Campus,
Mississauga, Ontario L5L 1C6

APPENDIX I

An example of data forms in use at Erindale College, University of Toronto.

Data Form No. 1 PLANT ECOLOGY RESEARCH University of Toronto

STAND RECORD FORESTS STAND NO.

Name: Locality:

County: T: C: L:

Date: Observers:

Size of Stand: Size of Area Sampled:

Forest Type: Soil Type:

Topography: Slope: Directions

Condition of Stand:

Open Grown Trees: % Canopy:

Stumps:

1.	4.	7.	10.
2.	5.	8.	11.
3.	6.	9.	12.

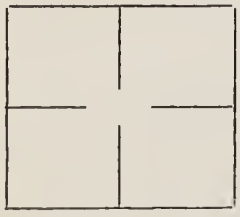
Soil Data:

	pH	N	P	K	Ca	Mg	Org. Mat.	Colloids	W.H.C.		
A_0											
A_1											
A_2											
B											

	DEPTH	CHARACTERISTICS (Colour, Texture, Structure, etc.)
A_0		
A_1		
A_2		
B		

Parent Materials:

Map:



Data Form No. 11 PLANT ECOLOGY RESEARCH University of Toronto

POINT RECORD TREES NORTHERN CONIFER-HARDWOODS STAND NO.

STATION NO.	1	2	3	4	5	6	7	8	9	10
Abies balsamea Balsam Fir										
Acer rubrum Red Maple										
A. pensylvanicum Striped Maple										
A. saccharum Sugar Maple										
A. saccharinum Silver Maple										
Betula lutea Yellow Birch										
B. papyrifera Paper Birch										
Fagus grandifolia Beech										
Fraxinus americana White Ash										
F. nigra Black Ash										
Ostrya virginiana Hop Hornbeam										
Picea glauca White Spruce										
Pinus banksiana Jack Pine										
Pinus resinosa Red Pine										
P. strobus White Pine										
Populus balsamifera Balsam Poplar										
P. grandidentata Large-tooth Aspen										
Populus tremuloides Trembling Aspen										
Prunus serotina Black Cherry										
Quercus rubra Red Oak										
Thuja occidentalis White Cedar										
Tilia americana Basswood										
Tsuga canadensis Hemlock										
Ulmus americana White Elm										

% Canopy
Distance

Data Form No. 13

PLANT ECOLOGY RESEARCH

TREE DATA SUMMARY SHEET

OF NORTHERN CONIFER-HARDWOOD FORESTS

University of Toronto

Average Canopy:

Stand Number:

Tree	# PTS	# TRS	DOM. CLASSES -80	-320	321	TOT. DOM.	# SAP	D. % SAP	F. % SDL.	F. % TRS.	% SUM F.TR.	D. % TRS.	DOM % TRS.	DFD INDEX	ORDER OF IMPORTANCE
Abies balsamea															
Acer rubrum															
Acer saccharin.															
Acer saccharum															
Betula lutea															
Betula papyrif.															
Fagus grandif.															
Fraxinus amer.															
Fraxinus nigra															
Ostrya virgin.															
Picea glauca															
Picea rubens															
Pinus banksiana															
Pinus strobus															
Pinus resinosa															
Populus grand.															
Populus tremul.															
Prunus seratina															
Quercus rubra															
Salix nigra															
Thuja occident.															
Tilia americana															
Tsuga canadens.															
Ulmus americana															
Quercus alba															

AVE. DIST. BTW'N TREES: AVE B. A.1 # TREES/ha: DOM./ha:

APPENDIX II

PLANT ECOLOGY LABORATORY

ERINDALE COLLEGE - UNIVERSITY OF TORONTO

MARSHES

October 19, 1977
P.F. Maycock
Biology 330 Class

Stand 10063 - Credit River Bridge

Sparganium eurycarpum - Typha latifolia Marsh

Location - just S. of Queen Elizabeth bridge, W. side Credit River, Toronto Twp., Peel Co., S. Ontario

Size - 2 acres

Location - on silty floodplain along W. bank, Credit River, separated by narrow Channel. 400 yds. s. of Q.E. bridge.

Situation - on w. edge of silt-clay bar on w. side river. Slowly decreasing in elevation toward west. At highest point only foot above river level. Deeper water covering soil surface on w. flank.

Vegetation - dominated almost completely by Burr reed - *Sparganium eurycarpum*. *Typha latifolia, Rorippa islandica* and *Urtica procera* are scattered vasculars. *Lemna minor* forms a floating component - more abundant where surface water is more prevalent. An algal film covers most of ground surface.
Community is generally depauperate in species.
Occasional drift materials especially logs. Heavily flooded in spring.
Surrounding vegetation - *Typha latifolia* marsh and open water. Boundaries distinct.

Quadrats:

		Frequency
Sparganium eurycarpum	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	(95)
Typha latifolia	1, 9, 10, 13, 15, 16, 17, 18 (40)	$\frac{19}{20} \times 100 = 95$
Polygonum coccineum	13, 17 (10)	
Rorippa islandica	5, 7, 8, 12, 17 (25)	
Scirpus acutus	(1)	
Sagittaria latifolia	15, (5)	
Lemna minor	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 14, 17, 19, 20	(70)
Urtica procera	1, 8, 9, 13 (20)	
Scutellaria epilobiifolia	1 (5)	
Epilobium coloratum	5 (5)	
Carex lacustris	(1)	

Site Region - 7
Saturated
Clay
Normal

Percent Cover 95%, 60%, 90%, 75%, 85%, 95%, 65% 60%, 80%, 90%, 50%, 90%, 75%, 85%, 50%, 95%, 70%, 90%, 90%, 90% Av. % cover = 77%

Structure - Tall herb layer - 5' - continuous - *Sparganium eurycarpum*. *Typha latifolia* emergent to 8'.
Low herb layer - 2½' - sparse and discontinuous - *Urtica procera, Rorippa islandica, Polygonum coccineum*
Floating herb layer - 0' - sparse but discontinuous - *Lemna minor*
Algal herb layer - 1" - sparse

Order of dominance - *Sparganium eurycarpum - Typha latifolia - Rorippa islandica - Urtica procera - Lemna minor*

Moisture - SATURATED - at sampling water table - 2-3" above surface - flooded extensively in spring - water very cold at time of sampling

Stand 10063 continued.

Soil - 3-4" litter - dead *Sparganium*
1" lt. brown clay silt
4-5" clay silt with roots
Then lt. brown clay silt 10"+
Field pH of top soil - 7.6

Microclimate - normal
- warmer nr. Lake Ontario - but colder in river valley

8.3 WILDLIFE

J.F.S. Bendell
Faculty of Forestry

J.B. Falls
Department of Zoology

University of Toronto

8.3.1. INTRODUCTION

What is wildlife? The term usually refers to all kinds (species) of animals that are not domesticated. Even domesticated animals that have "gone wild" may be included. Thus, wildlife can mean the whole animal kingdom. Following popular usage, however, this section will deal mainly with birds and mammals, with briefer reference to reptiles and amphibians.

Why include wildlife in an environmental assessment? If we ask ourselves why we want to protect natural areas in the first place, the reasons become obvious. Together with plants, wildlife provides relief for the city dweller from the continuous impact of buildings, pavements and crowds. They are at once beautiful and full of interest; some would say that we need contact with them to preserve our sanity. Thus, wildlife serves recreational needs in the broadest sense, including physical and mental well being.

Urban natural areas provide an important educational resource not only for students but for the public at large. Remember that it is mainly city dwellers who make decisions affecting the environment. What better way to foster an appreciation of our dependence on natural processes and instill conservation values than through the study of wild animals in natural environments?

Related to education is research that seeks to unlock knowledge of the working of nature. Wild plants and animals provide material conveniently available for study in areas close to cities.

Finally, we include a survey of animals in our environmental assessment because they provide a measure of the quality of the environment. Though a few species thrive in even the most degraded surroundings, a variety of animals occurring in reasonable abundance indicates healthy habitat, ours as well as theirs. While some species like the robin are relatively insensitive to habitat change, others such as the song sparrow require particular conditions and are good indicators of the state of the environment. Partially degraded areas may recover in time and a knowledge of wildlife in similar but undegraded habitats helps to assess the potential of an area if it is properly managed.

Proper management is a subject in itself and must be considered in any plan of protection and conservation. Change is inevitable in nature and one must decide whether to let nature take its course or whether to intervene. In many cases we can, and must manage natural areas to obtain the greatest good from them. One should always consider the potential of an area no matter what its present state. A first essential step in a management plan is to understand as much as possible of the requirements of the plants and animals that live, or might live in the area.

8.3.2 NATURAL AREAS AS WILDLIFE HABITAT

Habitat refers to the environment of a species, the sort of place that provides for its needs. As such, habitat embraces physical features like soils and local climate, as well as the vegetation and other animals with which a particular species interacts. The important requirements of animals are for food, shelter and nest sites. These needs differ among different species as do tolerances for physical conditions and the types of other living things that represent a threat to their wellbeing. Therefore, different species need and select habitats that differ to a greater or lesser extent.

Conversely, different types of habitat harbour different groups of species. Those plants and animals that occur together in a habitat constitute a *community*.

Communities vary across an area as the habitat changes. When we see a gradual change, it is likely that some underlying physical factor such as moisture of the soil or amount of sunlight is involved. An abrupt change in habitat and animal life can be expected to coincide with a sharp break in the physical environment such as occurs at the edge of a rock outcrop or a pond.

Human and natural disturbance can bring about marked changes in plant and animal life such as occurs at the interface between field and forest. If nature is allowed to take its course, shrubs and trees may invade the field and, over a long period of time, the field community may be replaced by a forest community through the process known as *succession*. Animals as well as plants are involved in such changes. Since environments are never completely stable, especially in urban areas, we should not be surprised to find that communities are continually changing.

Besides long-term changes, there are changes that occur with the seasons. Thus, some animals are permanent residents, some appear only in winter while others come in summer; some breed there while others are only temporary visitors (transients). Each of these groups makes different demands on the habitat. Even over a 24 hr period, the kinds of animals that are active differ between day and night. Habitat is fundamental to the animals that live in an area and may be essential to other animals that use it in migration.

The animal component of a community can be described by the number of species present and their relative abundances. If a community includes many common species, we consider it *diverse*. If fewer species are present or if only a few are common, we consider the community to be less diverse. Several numerical indices have been devised to measure diversity in these terms. If you wish to pursue this subject or learn more about principles relating to communities and habitats, consult a text such as Krebs (1979).

What has all this to do with protection of natural areas? It should help us to compare areas and to understand the significance of a particular area for wildlife conservation - for example, consider how areas differ in animal diversity. In general, larger areas contain a greater variety of wildlife. They are likely to have more varied habitats and can meet the needs of more species. Also, more members of each species can be accommodated. By contrast, a small area, especially if it is isolated, can support only a few animals and, if these disappear, they may not be replaced. Thus, larger natural areas serve as reservoirs for animals that will disperse into the surrounding region. Also, areas that are connected to natural corridors for dispersal, such as ravines, will likely have more kinds of animals than will isolated areas. Apart from these factors, the variety of animals depends on the variety of habitats. An area which includes edges between different habitats is likely to have the greatest variety of plant and animal life.

Thus, wildlife provides us with a means for comparing areas and for monitoring changes in an area over time. Obviously, high diversity makes an area interesting. But we should not consider this our only criterion of environmental quality, because some interesting species, including those found in old forests, require substantial tracts of fairly uniform habitat.

In this section on wildlife we will consider the kinds of animals and how they can be inventoried. Our account will be confined to methods suitable for relatively small animals; we are not likely to encounter such things as bears - although what we say can be modified to work for them too.

8.3.3 WHAT GROUPS TO STUDY

In surveying the wildlife of an area, it is desirable to obtain as much information as possible about all kinds of animals, but some groups lend themselves more readily than others to this type of study. Therefore, one's efforts should be invested so as to do the most good and the least damage.

BIRDS

Birds are an important part of the urban environment for a number of reasons. They are relatively easy to observe and identify, and experts on birds are available to help. They occur in a wide variety of habitats, each species seeming to show a preference for certain habitats. They respond quickly to changes in habitat and seem sensitive to the types of habitats (and changes) that we recognize such as woodlands, edges, fields, wetlands. There are enough species of birds to provide a reasonably sensitive index of the types and quality of environments. Perhaps most important for the preservation of urban wildlife habitat is the fact that most people perceive birds as an attractive amenity. They are pleasing to the eye and ear, interesting to observe, and readily attracted to feeders and artificial nest sites. A few species damage crops and deface buidings. Although variety is reduced in urban habitats, numbers of individual birds are greater in cities than in wild areas. Even in cities, many species are present during migration. A good example of a survey of urban birds is the work done in Toronto by Savard (1978).

MAMMALS

Mammals are attractive and interesting, as much or more so than birds when they can be observed. They are more specific to particular habitats and many of them occur in cities. However, apart from a few species like squirrels, mammals are secretive or nocturnal in habits and, therefore, difficult to study. Compared to birds, more of them are permanent residents. Some are regarded as pests because they destroy property, scatter garbage and, in a few cases, spread disease. Krebs and Wingate (1976) provide a fine example of a mammal survey.

REPTILES AND AMPHIBIANS

The presence of snakes and turtles indicates an undisturbed area for the unfortunate reason that, although they are nearly all harmless,[1] people often kill them. Care should be taken not to disturb these animals or their habitats. Several Canadian species are now placed on the endangered list. The terrestrial amphibians (newts and salamanders) are particularly vulnerable to disturbance. Frogs and toads are easier to study and their variety indicates the variety of habitats present. They are dependent on ponds for breeding.

8.3.4 DESCRIPTION OF HABITAT

A first step in the inventory of wildlife is to decide what area you are interested in and what level of study you want to undertake. Generally, any effort is worthwhile as long as you observe carefully and take careful and complete notes. As you make your search, you will see that animals are distributed in patterns that reflect the kinds of habitat that they prefer. While listing species and the abundance of them observed in an area is useful, a more revealing kind of survey is obtained by relating wildlife to their habitats. In this method, one classifies and maps the study area into habitat types. This approach makes inventory easier and more accurate and also helps to identify what features of habitat are important to wildlife. Inventories should be made in all habitat types and the results expressed separately for each habitat. Where results are similar, they may be pooled to yield an estimate for the entire area.

The classification of habitat can lead into great detail. You will probably want to work in three broad kinds of habitat: forest and field, aquatic and wetland, and urban and suburban. The main features of these habitats relevant to wildlife are shown in Fig. 8-3. As an example of how the mapping might go, consider a woodlot. Half of it might consist of a stand of sugar maple and beech, a quarter

[1]The only dangerous reptiles in Canada are rattlesnakes which occur locally in a few places.

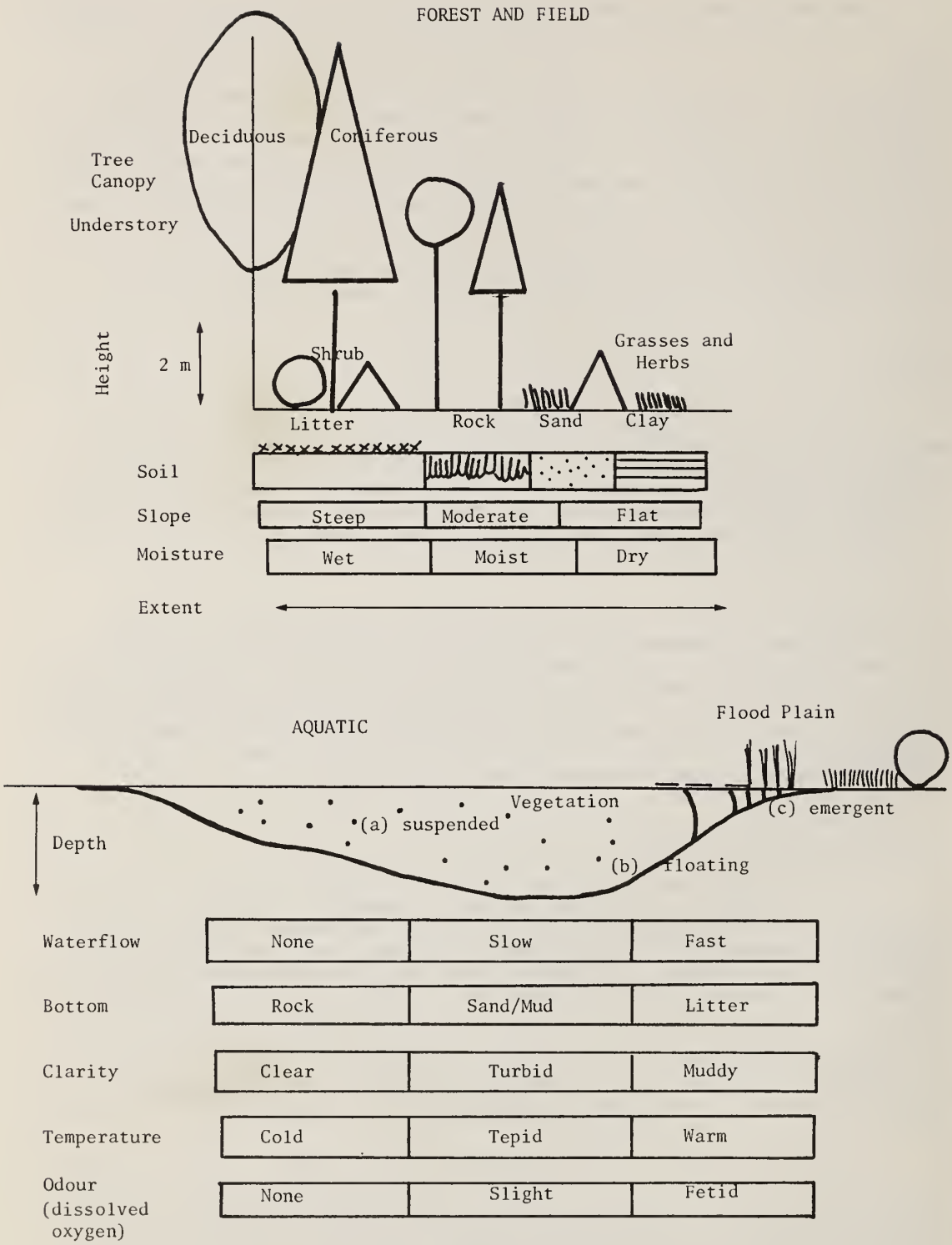


Fig. 8-3. Features of habitat important to wildlife

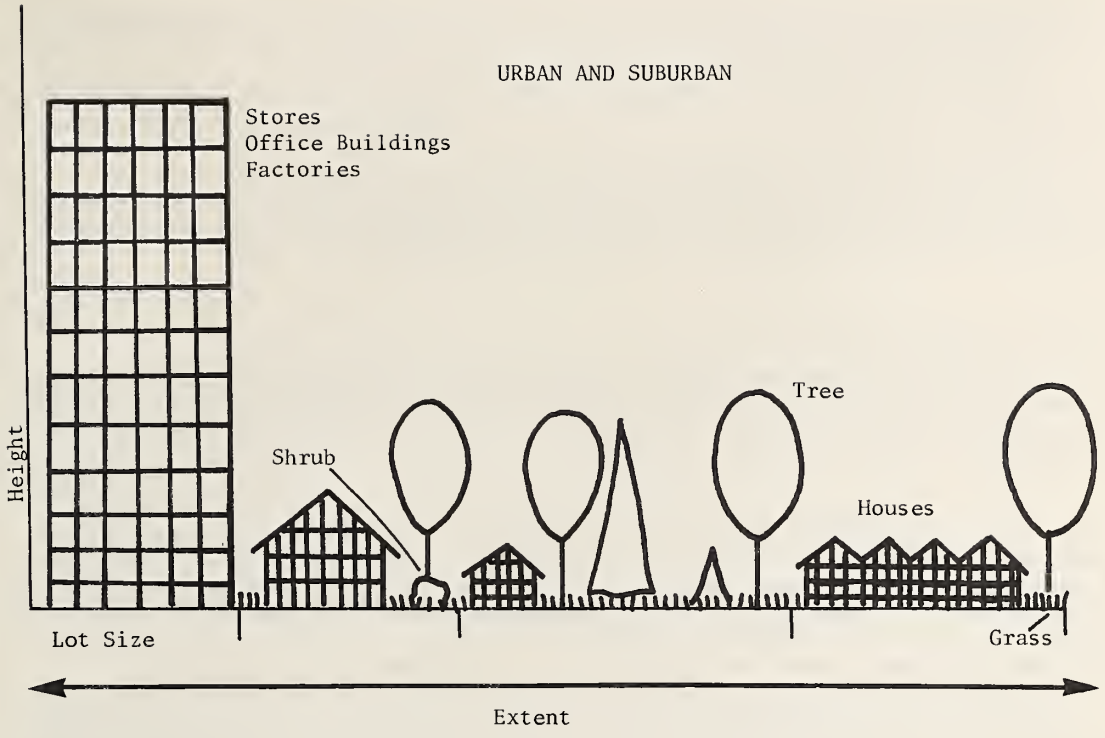


Fig. 8-3. Features of habitat important to wildlife

is in hemlock, pine and white and yellow birch, and the remainder consists of a thicket of white cedar. A simple beginning is to identify the habitat types; deciduous, mixed deciduous and coniferous, and coniferous; then map them. Once mapped, each type can be described in the terms shown in Fig. 8-3.

In addition to what is illustrated (Fig. 8-3), features of habitat that may be important to wildlife are direction of slope in forest and field, and percent coverage by pavement in the urban and suburban landscape. Section 8.2 lists what to record when studying plants; some measurements mentioned there may be used or modified for analysis of wildlife habitat.

The diversity of vegetation has a major influence on the species composition and abundance of wildlife (e.g. Hooper *et al.* 1973). Varied habitat is provided by the life form (structure) of the vegetation at all stages of growth. Beyond noting features of habitat illustrated in Fig. 8-3, you may want to identify species of plants as another measure of diversity.

It may be desirable to measure quantitatively certain features of the habitat. As with censuses, to be discussed later, samples may be taken and estimates made for the whole habitat type. Measures that you might obtain are as follows:

Total Cover - Percent of ground covered by all vegetation; trees, shrubs, grasses and herbs. Include all parts of the plant that shade the ground in arriving at an estimate.

Percent Cover Composition - Percent of total cover provided by each of: deciduous trees and deciduous shrubs, coniferous trees and coniferous shrubs, and grasses and herbs.

Total Ground Cover - Percent of ground covered by all of: stems of woody vegetation, grasses and herbs, logs and stumps, litter, and mossses and lichens.

Percent Ground Cover Composition - Percent of total ground cover provided by each of the above (in total ground over) and rocks, and bare soil.

When making descriptions of habitat, record special features that may be important to wildlife, e.g. roost and den trees, supply of fruits and seeds, and broken rock.

With criteria for habitat types in mind, it should be possible to make a map of the study area showing the kind, location, and extent of each type of habitat. Then a wildlife inventory can be undertaken for each patch.

8.3.5 WILDLIFE INVENTORY

Once the habitats are mapped, we want to know the animals in the area, where and when they are to be found, and in what numbers. The depth of answers we get to these questions will depend on the effort invested in the study and the expertise available.

There is no single inventory method that is satisfactory for all wildlife. In this respect, animals are more difficult to deal with than plants. Many species and even stages of life history of single species may require different techniques to do the job. For example, white-footed mice are readily captured in certain traps, while jumping mice are not. Fortunately, some methods do work for a variety of wildlife. However, one should prepare oneself in advance by learning as much as possible about the animals to be expected in a particular area.

Birds may be identified by sight and song. Identification is aided by the use of binoculars (7x35 or 7x50) and, in some cases by taking a tape recorder into the field and playing bird songs to encourage singing and thereby the conspicuousness of resident birds. It is not easy to observe all species at all times. Some are active only at particular times of the day or night and activity will also vary as the mood of an individual changes under the influence of internal and external factors. Thus, birds sing most in the early morning (there are exceptions) and in the early part of their annual nesting cycle. Their singing is reduced on cold and windy days. These variations in behaviour must be taken into account by searching the area at all times and under a variety of conditions. Similar considerations apply to other animals. Day-active mammals like chipmunks and squirrels may be observed like birds, but many other species are secretive. Some of these can be captured alive using pitfalls or baited live-traps or killed using snap traps. Even without traps, baited areas may lure mammals into view. Of course, feeders also attract birds. Reptiles and amphibians may be seen basking or when they betray their presence by movement if they are startled. The voices of frogs and toads will help in their identification. Aquatic forms such as turtles, frogs, tadpoles, and some salamanders may be netted from ponds. Small snakes and terrestrial salamanders pose a problem, because in searching for them it is easy to injure these animals and damage their shelters which include logs, rocks, and other debris on the ground. Particularly in remnant natural areas in cities, it may be best not to hunt for them but to rely instead on what they reveal of themselves. A compromise would be to set out boards or other shelters and, after several days, see what animals are to be found underneath. For all animal groups, signs such as tracks, droppings, evidence of feeding, and nests may help to detect the presence of rare or shy species.

The use of traps to obtain dead animals was mentioned above. This is commonly done in scientific studies of large areas, without appreciable effect on natural populations. The specimens obtained permit accurate identification and provide a variety of information on internal condition, which is difficult to obtain from live animals. They may be deposited in museums for further study. Before taking specimens, federal and provincial and, in some cases, local permits are required. In small natural areas, however, one should interfere as little as possible with animals and their habitats. Specimens should only be taken of common species and only when this is necessary to the study. Live trapping is much less disruptive and provides information on movements and many other data. Schemnitz (1980) describes many techniques for censusing, catching, handling and examining various kinds of wildlife.

Depending on the type of inventory to be carried out, a reference grid of regularly arranged points may be helpful for locating observations in the field. A grid can be laid out using a good hand compass and tape, and intersections marked with flagging tape or painted stakes marked with a black grease pencil. A grid interval of 20 m is commonly used.

For any kind of inventory, some system of careful and complete note-taking is required. Cards or notebooks may be used or observations may be plotted on maps of the area in the field.

8.3.6 FAUNAL LISTS

A list of fauna present in an area is the first concrete result of a wildlife inventory and will be sufficient in many cases. A good list conveys a great deal of information to a knowledgeable person. It indicates the types and variety of habitat present and the occurrence of rarities or particularly desirable species that may need special protection. It helps to diagnose the quality of the area. It also indicates the thoroughness and competence of the survey.

Usually, animals are listed in columns, following a standard order, which may be found in published checklists or identification guides. It is not necessary to use scientific names for birds, mammals, reptiles and amphibians, provided references are given to standard sources from which common names are taken.

The value of a list depends on its completeness and the accuracy of identification. Completeness depends on searching thoroughly at all times of the year and in all types of habitat. Information over many years may be available from local scientists or naturalists and adds rarities that occur infrequently or species that were formerly present.

Accuracy of identification without specimens poses a problem. Where rarities are concerned, good photographs or concurrence of several experienced observers provide acceptable evidence. Local experts such as competent naturalists, museum staff, or biologists in universities or government ministries may be able to help. An experienced person can tell by examining your list whether or not it is relatively complete and which identifications are likely to be in error.

The value of a list is greatly enhanced by annotation in various ways. The most important additional information concerns where and when a species has been found and what it is doing; feeding, singing, resting and the like. As far as possible, faunal lists should indicate in which habitat(s) a species occurs. Particularly for migratory birds, but also for other forms, season or dates of occurrence are important. Such information not only helps to indicate the significance of an area for wildlife conservation but also provides valuable interpretive material for educational and recreational use. For such purposes, anything that indicates when and where a species is likely to be encountered will be useful. It is also helpful to include information about relative abundance (see below). The uses which animals make of an area are helpful in understanding how important the area is to maintaining species. Information about breeding (nesting), feeding, and shelter is particularly valuable.

Many published local lists of animals illustrate all these kinds of annotation. A list for a nearby region or one that includes the area in question can be very helpful but the list for a particular place should be based on species known to occur there and should be documented appropriately.

8.3.7 CENSUSES

The wildlife census involves some form of counting the number of animals or species of animals in an area. The annotated list is perhaps the simplest form of census. Censusing may be quite complicated; however, this need not prevent us from getting useful estimates of numbers. A main problem in censuses of all kinds is the difficulty of counting or sampling all members of a population or species in an area.

Hence, unless corrections are made, most estimates of total numbers will be in error. There is a large literature dealing with censusing and census methods (Caughley 1977; Schemnitz 1980; Southwood 1966; and others).

Counts of wildlife are important for a number of reasons. Wildlife generally show seasonal changes in abundance reflecting the production of young. Populations may also show different levels of density, and trends of increase and decrease. Clearly, while species lists remain the same and cause no concern, a steady decline in the abundance of a desired species, or the failure of a population to produce young are causes for alarm. Since numbers are linked to the quality of the stock and habitat, changes in numbers may indicate changes in habitat that we may wish to prevent. For example, the increase in abundance of many species of ducks and geese along the Toronto waterfront (Goodwin *et al.* 1977) suggests that this habitat may be improving in its ability to support many wintering waterfowl.

8.3.8 RELATIVE ABUNDANCE

Census methods fall into two main classes, *relative* and *absolute*. Relative methods do not attempt to measure the actual numbers of animals present; instead they provide an index of abundance based on the number of animals encountered per unit of search. Relative methods are sufficient for most purposes. They are generally easier to carry out than absolute methods and provide measures of the relative likelihood of encountering each species in an area, which is generally what people want to know. They may or may not indicate the relative abundance of different species, because some are easier to find than others. Despite this limitation, relative methods allow comparison of different habitats or areas based on animal counts. They also reveal trends or changes in abundance over time or from place to place. To get comparable information, it is necessary to standardize the method of search. Measures of search might include area censused, time spent and number of observers. For example, a bird census might consist of walking from point to point and counting the number of singing individuals at each site for a standard period of time. This is a good example of a relative method, since we do not know what fraction of the birds we missed, from what area the birds that were recorded were drawn, and the number of cases of double counting. Still, the results enable us to compare the variety of birds and relative abundance of many species from one habitat to another.

A simple way to use an index of relative abundance to extend a bird list into a census is to note how frequently a species is encountered over a number of bird walks. Then each species can be classified as to frequency of sighting as:

Abundant	90 - 100% of walks
Common	65 - 89%
Moderately common	31 - 64%
Uncommon	10 - 30%
Rare	1 - 9%

8.3.9 ABSOLUTE ABUNDANCE

The census of absolute numbers provides the total number and density (numbers per unit of area) of a species. It is generally the most difficult census to obtain yet provides the most information. Total counts, properly done, are the most accurate census and lend themselves to more detailed studies of wildlife than other estimates of abundance. For example, if we want to find how many young are exported from a particular habitat, then we must know the absolute number of adults and the young they produce.

There are two ways of estimating absolute abundance, by a total count or by estimating abundance by sampling. If the total count of an area is indeed a complete count, then it needs no qualification. One might get a total count of all nests of Canada Geese on Toronto Island, for example. But it is difficult to get total counts because areas are often too large to cover completely, or there are too many animals to permit a count of every one. Hence, one samples a small part of

the habitat and extrapolates to estimate the total number in the habitat type. One takes at least 3-5 samples from different parts of an area. Take care to make the samples as representative as possible of the habitat type. A rule of thumb is to sample about 10% of the total area for which an estimate is to be made.

One may estimate many attributes by sampling, for example, plant cover, species lists, relative abundance, and absolute abundance by sampling. In a census by sampling, there is no way to determine the accuracy of the value derived for the whole area short of some sort of total census against which to check your estimate. However, there are ways of looking at your data that indicate the accuracy and precision of sampling:

(a) As you sample, the cumulative number of new individuals encountered should level off as the number of samples increases (Fig. 8-4). The point where the curve begins to level off indicates when sampling could stop.

(b) Where there are a number of individual sample counts they should be close replicates or deviate no more than 10% from their mean.

(c) The greater the number of samples taken, the greater the precision of the estimate. If the individuals of a population are randomly or uniformly distributed, about 66% of the samples should be within one standard deviation of the mean. Moreover, with each group of samples, the mean of samples should equal the mode. If the difference between the mean and the mode is greater than one standard deviation, then the samples are probably from different populations and the density of the species varies significantly over the area sampled.

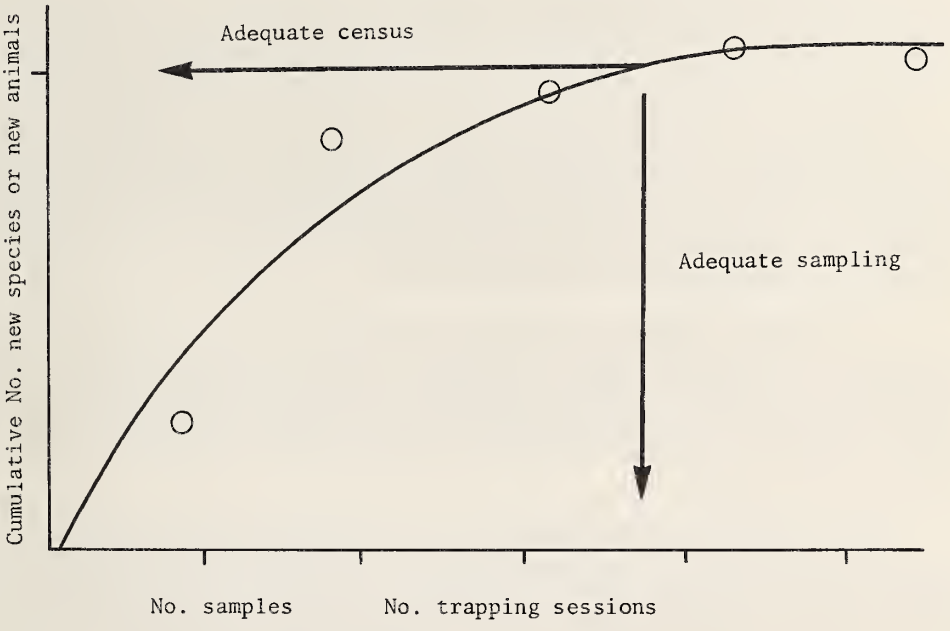


Fig. 8-4. Graphic method to determine a best estimate of number of species in a habitat (or number of individual animals)

8.3.10 CENSUS OF BIRDS

Estimates of relative abundance

The conspicuousness of birds makes it relatively easy to obtain good estimates of their relative abundance with very little effort. A simple technique is to walk a distance, say 200 m, stop, and count all the individual birds heard in 3 min, then walk to the next station and repeat the procedure. The average of some 10 stations should give a good measure of average number of species plus the average number of each species heard per 3-min count. Versions of this method are used in the American and Canadian Breeding Bird Survey (Erskine 1978). Other relative methods consist of counting birds along a transect line of known length which may be traversed in a standard period of time.

Estimates of absolute abundance

A transect count can be turned into an absolute estimate of density if we know the width of the strip within which birds can be reliably detected. This can be attempted in various ways. Some animals reveal themselves by jumping up or flushing in response to an observer. Flushing distance can be used to estimate an average width of strip censused. Ruffed grouse, varying hare, bullfrogs and perhaps some snakes may be estimated by this method. Many studies, some quite recent, have shown the usefulness, in a variety of habitats with a range of wildlife, of the King strip census method developed in the 1930's. King's method is described by the formula:

$$N = \frac{nA}{2LR}$$

where A = area to be censused;
L = length of census line in A;
n = number of animals seen;
N = estimated animal population; and,
R = mean sighting distance.

The calculation 2 x L x R yields the area of the strip for the derivation of density.

Another approach using transect lines is to count birds only within a fixed distance of the line. This is based on experience with the species and the habitat. For example, a strip 150 m wide may be censused, representing twice the distance within which a bird may be reliably heard from the transect line. In effect you are censusing a long narrow plot. More often, sample plots that are square or broadly rectangular are used to census breeding birds.

A recommended method for making an absolute census of birds is to map the occurrence of singing males on a square plot. The plot may be the study area or one sample plot. An observer covers the area at times of peak song. To use this method, it is necessary to know the songs of different species. The census is repeated at least 3-5 times and a map is compiled of the territories of individual males. The number of males is converted into a calculation of density per hectare (ha) of a particular habitat type.

Sample plots may be as small as 2 ha in size, although 4 to 10 ha is more usual in large areas of homogeneous habitat. A transect may be marked by a line of stakes 20 m apart, while a plot is marked by a grid of several parallel lines. Each stake is numbered so that observations may be plotted accurately on a map of the plot or strip. Thus, the observer walks along one line for a transect and up and down adjacent lines for a broader plot, being careful not to miss birds or count the same bird twice.

In all plot work, there is the problem of territories that overlap the census area and complicate calculations of density. The interested reader is referred to MacLulich (1951) who gives an elegant solution to the problem as well as illustrating techniques of census of small mammals. A rougher but simpler solution is to count only half of each breeding male in the overlapping territories, rounding off any remaining half male to the next higher number.

8.3.11 CENSUS OF SMALL MAMMALS

The census of small mammals is similar to that of birds; break the study area into habitat types, census each type, then combine the results for an estimate of the population of the whole area. Mammals are more secretive than birds and one must work harder to gather data. Large mammals and those that make calls can be censused directly as described for birds; or a walk through the habitat may yield data on relative abundance, e.g. moose seen or red squirrels seen or heard per hour. However, for the small and secretive mammals, one generally begins with a square plot or trap-line (really a transect) and spaces trapping stations 20-30 m apart in a grid, or a long line (Calhoun 1956). You should attempt to cover at least 2 ha with your sample plot; larger areas are generally better.

There are three general methods of detecting small mammals, by sign, dead trapping, and live trapping. The first is the cheapest and does not require handling the animal, but it also yields the fewest data. Census by sign such as droppings and tracks may yield useful estimates of relative and absolute abundance.

Dead trapping with snap traps such as the Victor mouse trap is more expensive and has the disadvantage of killing the animals. Live trapping with Sherman or Longworth live traps (Schemnitz 1980) is the most expensive but yields the most data. Live and dead trapping are the best way to estimate absolute numbers.

In catching, holding and marking animals, it is most important to use humane methods. Interfere with them only when necessary and treat them so as to cause the smallest possible amount of harm. Consult the current federal handbook on the care of wild animals. Baiting is a standard practice in attracting small mammals to traps; a usual bait is peanut-butter and oatmeal mixed to the consistency of soft putty.

When animals are confined in live traps for any length of time, they should be provided with food and bedding. Dog food, mixed grain, and dog biscuits will serve as food and a handful of non-absorbent upholstery cotton makes good bedding.

A simple form of live trap can be made with a metal bucket or a length of stove pipe inserted into the ground. Both must be deep enough so that mammals cannot jump from them. The buried end of a stove pipe should be closed with fly screen. When used as live traps, the pitfalls are supplied with food and bedding. By putting water in the buckets they become effective dead traps. Pitfall traps catch an amazing variety and number of animals, including small mammals. They are a valuable addition to standard live traps in assessing numbers of voles (Boonstra and Krebs 1977).

When snap or live traps are used, one caution is that there should be more traps at a trapping station than animals caught, for number caught might be a reflection of the number of traps rather than the abundance of mammals. A second caution is that, in urban areas, traps and other equipment are frequently disturbed or taken by people.

Sampling by sign

The general idea is to count in a quadrat or circle at each station the sign, such as droppings or tracks, left by the animal. The quadrat may range from 10 cm^2 for small mammals such as meadow mice to 1 m^2 for rabbits and hares. The detection of sign can be enhanced by placing dropping boards, smoked paper, or sand boxes at the station. Dropping boards are 10 cm^2 pieces of masonite or sheet metal that some small mammals enjoy as toilets and so reveal their presence (Emlen *et al.* 1957). Smoked paper is made by holding white shiny paper over a smoky kerosene flame to obtain a light film of lamp black. The paper is then placed in a tunnel made of a milk carton opened at each end. The tunnel directs the mammals and protects the paper from becoming wet. Tracked paper can be enscribed and sprayed with plastic for storage. A sand box is a pan about 15 cm^2 and 1 cm deep, filled with fine sand and set flush with the surface of the ground. The sand is smoothed and, like the dropping boards and smoked paper, left out for a night and checked in the morning for sign. Bider (1968) has extensively developed the tracing of tracks using a sand

box in the form of a sand transect. He used the method to show that rainfall at night increases the activity of the masked shrew (Vickery and Bider 1978).

A census period for small mammals is from 3 to 5 nights or longer. Results can be expressed as number of droppings or tracks per station per night. If you know the number of signs made by an animal per night, it is possible to convert signs into an estimate of total abundance.

Snap or dead trapping

This is a standard technique for the census of small mammals. Usually, a series of trapping stations is established in a line. For this, 3 baited snap traps are placed in mouse trails or beside rocks or logs at each station. It is a good idea to attach a string to each trap and fasten it to some anchor, for traps are frequently shifted from where they are placed. Again, trap 3 to 5 nights and express the results as captures per trap per night. This relative index of abundance is as far as you can go unless you have other information to determine the area from which animals are taken.

If a trapping grid (plot) is used, the number of captures gives an estimate of numbers but it will be necessary to add some boundary strip to the plot to estimate the area trapped. MacLulich (1951) shows how to calculate the area sampled by traps so that captures can be converted into density. Another problem in trapping small mammals is that some animals come slowly to traps and take a long time to catch, if ever. Hence, when captures cease the population estimate may be an underestimate.

The catch curve of Hayne (1949) uses new and cumulative new captures by "trap night" (number of traps per night) to estimate absolute numbers (Fig. 8-5). As mammals are removed or tagged fewer new ones are caught in each trapping session. Make the points into a best straight line and project the line to intersect the abscissa. The value at the intersection is an estimate of the total number of mammals in the population.

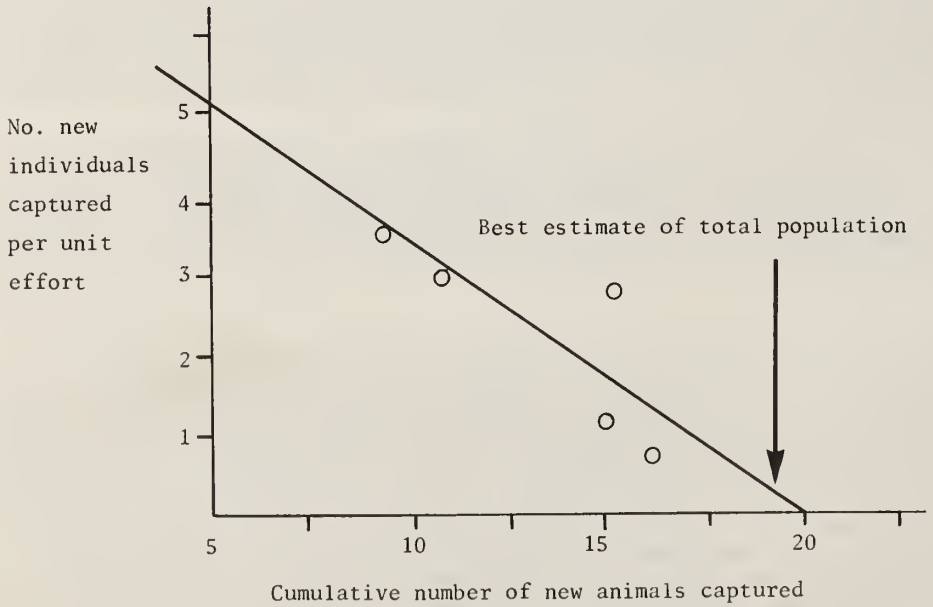


Fig. 8-5. Catch curve to best estimate total population from diminishing captures (Hayne 1949)

Live trapping

This is done by setting out live traps or sinking pitfalls into the ground at stations in a sampling grid. Live traps are positioned at each station as described for dead traps; if pitfalls are used, one per station will do. The traps are set in the evening and checked in the morning for captures. A trappping period is from 3 to 5 nights, the traps are then closed for 3 to 5 nights and then opened again for another trapping period, if desired.

The great advantage of live trapping is that animals can be returned to their environment with minimal disruption to populations and habitat. One important result is that numbers of animals tend to remain the same during census. Removal trapping may result in the invasion of the study area by outsiders to give an inflated count. In live trapping the same animal can be caught many times to get a continuous sample of its movement from trap to trap. Many other data can be obtained from the live animal. Animals can be marked with numbered ear tags or dabs of fingernail polish applied to the tail or coat. The paint is much less permanent than tags. A simple way to handle small mammals is to make them run upwards from the trap into a plastic bag or bag made of nylon netting. The animal can then be gently squeezed and manipulated to expose an ear for tagging or tail for painting, and so on. Pesola balances are useful for taking weight and are quite accurate. They can be purchased from Oskar Lüdi & Co., Waagen, Basel, Switzerland.

There are many ways of converting live trap data into estimates of abundance. One of the simplest is to continue trapping an area until no new animals are caught. Total individuals captured is then an estimate of numbers. Analyse the data as in Fig. 8-5. MacLulich's technique, as noted, will help decide how large an area is being sampled. As with snap traps, a line of live traps may be used to obtain a relative index of abundance.

8.3.12 CENSUS OF REPTILES AND AMPHIBIANS

Reptiles and amphibians pose special problems because they are relatively inconspicuous and do not come to conventional traps. Traps used for this group include pitfall, funnel and minnow traps. Start with the habitat approach and search each type of habitat carefully. This may be difficult or impossible in some parts of the aquatic habitat - although diving is great fun! Reptiles, such as lizards, turtles and snakes, have favourite basking spots; a search for these from time to time will yield a measure of relative abundance. Sand boxes may work for lizards and snakes and a count of tracks and nests at nest sites may apply to turtles.

Amphibians such as frogs and toads may be enumerated by a calling count, as with birds. One method, where large numbers occur in separate ponds, is to visit each pond, or a separate part of a large pond, and listen for 3 min. Try to get the number of callers and, if this is impossible, the number of calls per 3 min. If the singing is a blur of many individuals, then rate numbers on a scale of singing: none, very few, several, many, or very many.

Where frogs are easily seen and distributed over a large area, it may be possible to count them by the King strip count method.

Aquatic salamanders can be counted but only with a great deal of work. A simple method is to set minnow traps for them and treat the results as described for trapping small mammals. Terrestrial salamanders live in rotting logs, under rocks, and in the soil. A search for them causes great destruction to the habitat and should not be undertaken except in special cases. Tracks of salamanders may turn up on sand boxes or smoked paper. Another method is to place several boards on the ground at a station or from place to place through a habitat. Each board should be about 50 cm in length, 20 cm width, and 1 cm in thickness. The boards produce a microclimate that is attractive to salamanders and a variety of other creatures. An old board may collect mammal droppings on top and a salamander below! Good luck!

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8.4 TERRESTRIAL AND AQUATIC INVERTEBRATES AND FISH

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8.4.1 INTRODUCTION

By and large, the strictly quantitative methods frequently used in professional surveys for terrestrial and aquatic invertebrates and fish are bypassed here in favour of valid qualitative methods which generate comparative information on the relative importance of each type of organism in the urban natural area under study. For most purposes, and particularly for assessing the amount of disturbance and the probable functioning of the ecosystem in the area, this qualitative type of data is quite adequate.

Surveys of the types mentioned below would tax the resources of even the largest group that might be organized to work on any given urban natural area. Clearly then, a strategy is called for which selects one or two invertebrates or aquatic groups for particular attention. The choice will depend on the type of habitat being surveyed, the interests and special abilities of members of the survey team, and the availability of equipment or other resources required, as suggested below, for the type of survey contemplated.

After survey methods have been covered, suggestions follow for identification of material collected and means of assessing the significance of the resulting data. Throughout, methods are referred to by name; more detail can be obtained from reading any of the appropriate specific references to methodology listed at the end of this section.

8.4.2 TERRESTRIAL SITUATIONS: INSECTS AND OTHER INVERTEBRATES

For the purposes of many studies, field identification of invertebrates is sufficient. However, some studies necessitate careful classification. In such cases the animals must be killed, fixed and preserved for study by skilled amateurs or professionals. Make sure your study requires such positive identification before you kill organisms in an area you are trying to protect. You could lose you credibility!

FIXATION AND PRESERVATION

The simplest and most comprehensive method for killing, fixation, and preservation of invertebrate animals is immersing the freshly collected specimen in 70% ethyl alcohol. (In most cases, isopropyl or methyl alcohol may be substituted with slightly poorer results in one respect or another.) This is an excellent method of preservation for most kinds of insects, with the exception of adult Lepidoptera (moths and butterflies) and some of the larger adult Diptera (true, two-winged flies). These two insect groups must be placed in a gas chamber type of killing jar, dried, and pinned on insect pins to produce specimens that can be readily identified. The same technique for pinned specimens can be used for most relatively robust, hard-bodied adult insects, but is inadequate for a great many smaller and soft-bodied forms. When using alcohol preservation, it is essential to maintain the volume of insects added to the alcohol at a proportion of no more than one-half, and to replace the preservative with fresh fluid approximately one week after the collection is made. This keeps the preservative at full strength and prevents deterioration of the specimens.

Most kinds of arthropods can be preserved in alcohol as suggested above for insects. Other types of invertebrates, especially soft-bodied forms such as earthworms, nematode worms, snails and slugs, require diverse methods of killing, fixation and preservation. Some of these require relaxation of the living animal before it is placed in the fixation/preservative For terrestrial habitats, methods to be discussed below will concentrate on the collection of insects and other arthropods.

If there is an interest in other elements of the invertebrate fauna, one of the references should be consulted.

SELECTION OF SAMPLING SITES

The sites to be sampled should reflect the full range of microhabitats available within the natural area under study. Insect populations may be quite specific to a particular type of habitat and can vary considerably from point to point within an urban natural area of any considerable size. A common-sense approach will yield the most rapid results, for it is obvious that patches of weedy vegetation, open grassy spaces, dry slopes, wet slopes, marshy regions, forested areas, and cultivated regions will all have their own distinctive insect faunas. Each of these microhabitats should be sampled independently, and the collections from each one maintained separately. Only in this way can a true picture of the total fauna and its distribution within the area under study be appreciated. It is suggested that for general initial surveys, no attempt be made to subdivide the sites selected into plots. Instead, each site is collected as extensively as possible and the resulting specimens considered as an indication of the composite population of the area.

Within each site, one can sample the insects of each of a variety of subhabitats (soil, vegetation, aerial, etc.). Again, the precise location sampled and the choice of methodology will depend upon the practical considerations noted above.

SOIL

The insect and arthropod inhabitants of the superficial soils in urban natural areas may be found either on the surface of the soil in moist locations beneath rocks, logs, organic litter and other debris, or they may be burrowing within the top 5-20 cm of the soil itself. Species in the first category can be collected with the fingers or a pair of soft forceps and dropped directly into 70% alcohol by proceeding through the site and overturning every sizeable stone, log, board, etc., lying on the soil surface. Take care to replace each one exactly as you found it so that the unique, dark moist habitat that had been developed there will not be destroyed. Many specimens will escape by burrowing into the ground immediately upon being exposed to the light, but with a little practice, a quick eye and deft hand, a good sample of the principal types present should be obtained. Take care to look especially for very minute forms such as soil mites which can be picked up by causing them to adhere to the moistened tip of a camel's hair artist's brush and then floating them off in the alcohol of the collecting container. One can also set out a series of pitfall traps by imbedding small tin cans with the upper end removed into the earth, the open lip slightly below the soil surface. The trap should be covered with a loose fitting board or large flat rock. The bottom of the trap is filled with a suitable preservative, and the traps should be checked for collected specimens every couple of days, and no less frequently than once per week.

The fauna inhabiting the soil itself may be somewhat inefficiently sampled by spreading handfuls of soil on a dry white surface and collecting with forceps or a moistened artist's brush (for the smaller specimens) all animals which run out of the soil and across the white background. This method is slow; it may take several hours of warming and drying the soil sample before most of its fauna will leave it.

A considerably more efficient and less time-consuming method of extracting the soil fauna utilizes a simple funnel-shaped device termed a Berlese or Tullgren funnel in which the soil sample is supported at the top of the funnel and, as the soil slowly dries out, the escaping animals fall to a waiting container of preservative below. Construction of the funnels can be simple. This type of sampling is perfectly feasible during an initial faunal survey of an urban natural area.

It should be remembered that the inhabitants of the soil of any region are all relatively small creatures and will require at least a low-powered dissecting microscope for adequate sorting and identification. Also, since these animals have

been among the last to be studied by entomologists, the species are poorly known and identifications are generally much more difficult to make than of the insects and associated arthropods occurring above ground level. These two considerations should be taken into account when deciding whether or not to sample the soil fauna.

VEGETATION

Large numbers of insects and other arthropods, especially spiders, are found hiding in and around stands of herbaceous vegetation. The most commonly used and productive method of sampling this fauna is with an insect net called a sweep net. It is made of sturdy cotton cloth that will not easily snag on bushes or tear. One walks steadily through the vegetation sweeping the net back and forth among the foliage trying to knock insects into the open mouth. Every 10 or 15 sweeps, the knot of accumulated plant material at the tip of the net is removed, and the insect specimens are carefully picked out and transferred to the alcohol or the collecting container. Thousands of specimens of many orders of insects and all life history stages may be rapidly accumulated in this way.

For shrubs, saplings and small trees, where the vegetation is not easily accessible or would be damaged by ordinary sweeping, a second technique may be used. A white sheet or other large white surface is spread on the ground beneath the vegetation of interest and the stalk of the bush or sapling is banged, sending vibrations up to the leaves. Insects knocked out of the foliage fall on the white sheet and can be readily seen and transferred to alcohol.

Additional specimens from the vegetation can be obtained by carefully examining the plant, leaf by leaf, and removing especially those insects which have fastened themselves to a leaf, those that have constructed a shelter by folding a leaf over, and those that are living within swollen gall on the plant body. No further treatment is given here of professional techniques such as vacuuming the vegetation and litter for quantitative insect sampling.

AERIAL INSECTS

Insects on the wing in the study area can be collected with an insect net constructed of open-weave material of the sort normally used for collecting butterflies. Indeed, butterflies may be the most conspicuous element of this fauna, although one will also find many types of small and large true flies, dragonflies, and damselflies, and a variety of wasps and beetles. This type of sampling depends on speed and experience with the net, although these skills rapidly develop after a few hours of practice. A survey of the butterfly fauna alone may serve as a valuable indicator of the degree of disturbance of an area, for certain species are quite sensitive, while others can be found in a wide variety of different urban situations.

A second easily conducted survey of aerial insects consists of picking or netting all of the visitors to the blossoms of flowering plants within the study site. The samples obtained will vary with the flora present, with the time of year, and even with the type of weather at the time of collection. Nevertheless, it is a quick and relatively effortless method of obtaining significant samples.

The final readily conducted sampling technique is carried out during the dark hours of the evening and night. A light source, powered by A.C., D.C. or kerosene, is provided in the centre of the study area, and a white sheet is hung up immediately behing the light source as a reflector. This type of "bait" attracts a wide variety of moths and other night-flying insects. Such a survey by itself will provide large numbers of specimens, although many of them will be relatively difficult to identify. The results are frequently a good indicator of the kinds of nocturnal insect populations in the immediate area, but there is a distinct tendency here to attract strong-flying insects from many hundreds of metres distant from the sampling site.

Professional methods of sampling aerial insects with less effort, or at greater distances above the ground exist. Among these are the Malaise trap and various types of rotating net samplers. These, however, are not recommended for an initial survey.

PARASITES

Parasites of other fauna in the region (vertebrate animals in particular) may be collected if means for trapping birds, mammals, reptiles and amphibians are available. Frequently the parasitic fauna gives little information of interest about the specific study site, since it tends to be characteristic of the host animal and not of the area in which the host is found. There is, nevertheless, a relatively rich parasite fauna available in most urban situations consisting of fleas, lice, and many species of mites. Most of these fall into the category of ectoparasites and can simply be picked from among the feathers, fur, or scales of the host.

8.4.3 AQUATIC ENVIRONMENTS

DESCRIPTION OF THE HABITAT

Adequate description of the type of aquatic habitat sampled is important in delimiting the particular site being investigated, in the same way as recommended for site selection above. Since the important variables in aquatic habitats are perhaps less obvious than those for terrestrial habitats, they are enumerated here.

It is first desirable to obtain a description of the local topography and drainage patterns immediately around the pond or stream being surveyed. This should include a general description of the surrounding vegetation, and any cultivation of contiguous areas. Such data are important to point out the types of input of run-off, vegetation, terrestrial fauna, and chemicals into the body of water. The water itself should be described in terms of length of its perimeter, its surface area, and its depth, both near the shore and in the centre.

The type of bottom is extremely important in understanding the fauna of the water, and a survey should be made to determine how much of the bottom is composed of large rocks or stones, gravel, fine sand, mud, and finely divided organic particles of silt.

The quality of the water itself is a complex matter and it is commonly measured with a variety of different types of apparatus. The variables of interest in the initial survey which can be easily measured include temperature (almost any thermometer will do), pH (acidity, measured with readily obtained test papers which change colour) and turbidity (estimated by eye - water very cloudy, moderately cloudy, or clear). The rate of flow of stream water can be roughly measured with a floating object (one of the best is an orange) and a stop-watch, and should be expressed in metres per second. If samples can be sent to a laboratory for analysis, an attempt should be made to obtain estimates of oxygen, B.O.D., conductivity, concentration of specific ions (heavy metals, potassium, calcium, sodium, chloride, magnesium, phosphate, etc.) and coliform count.

SURVEY OF INVERTEBRATE FAUNA

As noted above for terrestrial habitats, there will be a tremendous number and variety of different kinds of insects and other arthropods and invertebrates in natural, unpolluted aquatic habitats. These faunas are unusually sensitive to disturbance and pollution of a variety of different kinds. Therefore, many aquatic habitats in urban areas have a greatly reduced fauna. Nevertheless, many different types of invertebrates may be encountered and, as before, while 70% ethanol is the best all-around preservative, especially for insects and arthropods, other types of animals will require special methods of fixation and preservation.

Fortunately, the methods of collecting aquatic invertebrates are somewhat less diverse than those needed in terrestrial habitats. The most generally useful pieces of apparatus are a long-handled, D-frame aquatic dip net, and one or more shallow white basins or trays. A dip net is worked through aquatic vegetation in standing water habitats, or through marginal vegetation in streams, much in the same way as the sweep net is used in terrestrial vegetation. Handfuls of vegetation from the net are placed in clear water in a white-bottomed tray and the organisms which swim out are readily picked up with forceps or an eye-dropper. Alternatively, the dip net can be used to sieve water after the bottom has been thoroughly disturbed by kicking with the boots.

In fast flowing streams with a stony or gravelly bottom, where there is not abundant rooted vegetation, an alternative form of netting is utilized. This is a simplified variation of the often described Surber sampler technique. A D-frame dip net is planted firmly on the bottom with the open bag facing upstream. The substrate material is thoroughly kicked up and disturbed with the boots for about 1 m upstream of the net in an area no wider than the net bag. Invertebrate animals of many types are released by this procedure into the flowing water and are carried downstream and into the net. The net contents are periodically dumped into clean water in a white tray and the organisms extracted.

The plankton (minute suspended organisms) of natural bodies of water can only be sampled with a very fine-meshed net usually called a plankton net. This net may be tossed from the shore or dragged behind a boat and, as it is pulled in, it strains many litres of water and extracts the algae and microcrustaceans that form the majority of freshwater plankton. These samples are relatively easy to collect but must be identified under the high magnification of a compound microscope. Thus, a plankton survey is a rather more specialized technique than the census of aquatic invertebrates described above.

SURVEY OF FISHES

The fish present in urban aquatic habitats generally can travel considerable distances. Thus, they do not tend to be as characteristic of the immediate conditions in the sampling site as do aquatic invertebrates. Nonetheless, for land-locked bodies of water and for many general indications, a survey of the fish populations can be instructive. The most obvious means of taking specimens, the use of hook and line, is also the slowest and most time consuming. A handy alternative is to institute a survey, by questionnaire, of all persons living within the area surrounding the habitat of interest and all those who are seen visiting the habitat or fishing there. This is the so-called "creel-census", and can yield valuable information from local fishermen as to the types and numbers of fish that have been taken.

The other methods generally used to collect fishes for faunal survey purposes include poisoning with Rotenone, electric shocking, and seining. For any of these, as well as the hook and line method mentioned above, one must be careful to observe all existing fishing regulations or to obtain specific exemption from them for the purposes of the survey. Rotenone and electric shock both have the potential for serious side effects in the ecosystem and should be attempted only by those experienced with the techniques. The use of a two-man seine, however, is an effective method of sampling the fish fauna for an initial survey and can be carried out in the following manner. One seine is erected across the stream, upstream of the sampling area, and fixed to the bottom with rocks to serve as a barrier. A second seine stretching from shore to shore with some slack between is slowly worked upstream by two persons holding onto the poles at either end. The assistance of a third person to disturb the substrate and scare out species that hide under rocks may be useful. When the upstream seine is reached, the moving seine is scooped out of the water and the trapped fish are transferred to buckets for identification. Should killing be necessary to permit accurate identification, fish may be killed and fixed in 8% formalin, after which they must be washed in water and transferred to 70% ethyl alcohol within 2-4 weeks.

8.4.4 RECORD KEEPING, IDENTIFICATION AND SOURCES OF PROFESSIONAL ASSISTANCE

All the collections should be accompanied by data labels. Scrupulous attention should be paid to the accuracy of collection information. The minimum data, as in all scientific collections, consist of locality, date, and name of the collector. In surveys of urban natural areas, additional information on the particular study site sampled, reference to any notes kept in a separate data book, and time of day should be recorded. On the data label accompanying the collection, or in a separate book, records should be kept of all the other characteristics of the site (weather conditions, temperature, etc.) that have been measured or observed at the time of collection. Data labels should be made of heavy weight, good quality, rag-content bond paper to withstand immersion in alcohol; information should be written with a heavy HB pencil or in waterproof india ink that has been allowed to dry thoroughly before immersion. There is a tendency, even in professionally planned projects, to skimp on recording field data because of the pressure of the time required to collect and preserve the samples. Yielding to such pressures can result in large amounts of worthless collections that cannot be analysed properly and represent the worst kind of pointless slaughter of living organisms.

Most of the invertebrate animals mentioned in this section, as well as the fish, can be identified more easily with the aid of a strong magnifying lens (at least 10X) or best of all a low-power, stereoscopic, dissecting microscope and a good source of illumination. The technical information necessary to make the most superficial identifications will be found in a number of the field guides and reference works listed at the end of this section. For more precise identification and expert opinion, one can resort to a number of sources. If you outline your problem and emphasize that only a limited number of example specimens need to be identified, the biology department of the nearest university can often provide several persons with experience. Alternatively, the same type of aid may be found in one department or another of the nearest museum with natural history displays. For insects and many other kinds of arthropods, the National Identification Service of Agriculture Canada can be contacted at the following address: Biosystematic Research Institute, Central Experimental Farm, Ottawa, Ontario K1A 0C6.

Some fishes are relatively easy to identify by reference to Scott and Crossman (1974) but, for more difficult families, professional assistance from a university or museum should be sought. In all cases where expert assistance in identification is required, remember that some specimens may be retained by the expert for his personal or institutional collections as a price for his service.

It should be emphasized that in all of the collections mentioned in this section, the number of animals obtained is equally as important as the species involved. Thus collections should be made with little attempt at selectivity, taking and preserving all of the animals that are captured by a specific method. During the process of sorting and identification, all the specimens should be retained (or at least counted) as to the relative importance of different insect or fish species in the communities of which they are a part. In more complex types of analyses, the size and weight of the specimens may also be of importance.

8.4.5 ASSESSING THE SIGNIFICANCE OF INFORMATION

The simplest method of analysing the data collected in the surveys described above is a total list of the various species or higher categories of classification that were found in the study site. This can in itself provide useful information, for particular groups of species will be characteristic of particular habitat types and certain sensitive species may be used to show the level of disturbance of the natural situation. Of still greater value is a record of the numbers of each species present, since this can suggest the relative importance of each species in its community. Further, samples taken at different times can show whether particular species are increasing or decreasing in importance. The total number of species present, of course, is an indicator in itself of conditions, for more disturbed habitats tend to have fewer species.

Periodic sampling of study sites is strongly recommended throughout an entire annual cycle. If possible, sampling should be continued for several successive years. The reason for this is that adult insects of various species tend to be present in the environment only at certain times of year. Thus, the apparent species composition of the fauna at a given study site will change gradually from season to season with the result that a single sample cannot hope to give a good picture of the entire year's inhabitants. Continued annual sampling gives a potential for detection of trends in the quality of the environment under study.

Once identifications have been obtained, further information on the nature of the communities represented can be obtained by the use of reference works to determine the biology of each species involved. Thus it may be possible, for instance, to assign each type of insect as a herbivore, a predator upon herbivores, as a predator or parasite upon other predators, or as a scavenger. Once this has been done and the relative proportions of herbivores, predators, parasites and scavengers have been assessed, a functional picture of the many food relationships within the community and a preliminary indication of the pathways of energy flow through this community have been established. Such analyses are far more indicative of the true nature of the community than simple species lists.

Additional studies that might be comtemplated after survey work has been completed include estimation of movement into and out of the study site by particular organisms, conducted by capturing large numbers of individuals, marking them in some distinctive way, and then releasing them again into the habitat. A second collection of individuals both inside and outside the study zone can give information on total population sizes of the species involved, as well as any tendencies for movement to or from the study site. One may also wish to refer to professional literature for details of particular quantitative sampling methods which will allow more precise estimates of the total number of organisms living in the area. This type of information, plus measurement on the dry weight of the individual organisms, can yield data which will allow an estimation of the total energy flow through the system. These kinds of calculations are of intrinsic ecological interest in themselves, and can be useful comparative indicators when trying to assess the relative importance of different locations within the urban environment and the effect of various artificial elements in the ecosystem.

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CHAPTER 9

SUB-SYSTEM STUDIES: SOCIO-ECONOMIC FACTORS

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9.1 INTRODUCTION

This chapter provides background information and an introduction to study methods relating to socio-economic factors. In many cases, particularly in urban areas, the social and economic impacts of a proposed project are extremely important, even to the point that favourable social and econmic impacts may win approval for a project that has significant adverse effects on "the environment". Alternatively, the identification of adverse social and economic impacts may help when field naturalists and other concerned parties seek to preserve woodlots, ravine lands, wetlands and wildlife habitats threatened by project proposals in urban areas. The interrelationships between subsystems are incorporated in Environmental Impact Assessment requirements in Canada, and these, almost universally, recognize that an attempt should be made to predict all significant impacts of a proposed project, including social and economic effects.

This chapter presents a non-technical overview of the principal issues and concepts involved in dealing with socio-economic factors for the purposes of:

1. better understanding the important interdependencies which exist within and between the component systems in urban areas;

2. providing a better understanding of the socio-economic factors themselves;

3. being better equipped to criticize an existing environmental impact statement (EIS) or planning document, as well as documents which support or are critical of its methods or conclusions.

This chapter is not designed to be a "how to do it guide", but it may be useful to a citizens' group preparing to review a published EIS, land-use plan or similar document. The reader interested in following up on the issues raised here is directed to the bibliography at the end of this chapter.

9.2 THE PROBLEM

The problem is essentially to *predict* the significant effects of a project and various alternatives on key social and economic variables to indicate how society will *evaluate* these effects. The evaluation is then integrated with that of other effects so an overall recommendation may be made about the best course of action. Chapter 6 describes how these two problems - prediction and evaluation - are handled in situations where EIA's are required.

The prediction phase requires a selection of key attributes or variables which are to serve as indicators of change. Table 9-1 provides the reader with an idea of the range of variables which might be short-listed. The table is first organized by class or type of impact (demography, local economy, etc.) and then into a set of key variables or indices which are usually particularly important. Finally, some other variables pertaining to the class have been listed.

To predict the effects of a project we need to have: (a) suitable baseline data on all variables of interest; (b) a prediction of changes in these variables with the project; and (c) a prediction of the changes in these variables without the project. In the physical and biological sciences the selection of variables and the prediction of their changes in response to some other change may be estimated from *theory*. Unfortunately there is very little good theory in the social sciences. Indeed this is a principal reason for the difficulty of socio-economic impact assessment and why so little agreement exists as to what variables should be included and how they should be predicted and evaluated.

Table 9-1. Socio-economic impacts: classes, indices and other variables

Class	Indices	Other variables where appropriate, measured as changes
A. DEMOGRAPHY		
1. Population	-Rate of population increase	-Birth rate -Percentage of population under 16 years -Percentage of population over 65 years
2. Migration	-Rate of immigration -Number of immigrants	-Average age of immigrants -Socio-economic status of immigrants -Ethnicity of immigrants
B. LOCAL ECONOMY		
1. Public fiscal balance	-Net change in government fiscal flow (revenues less expenditures and annualized capital expenditures)	-Total operating expenditures -Local tax rates -User charge revenues
2. Employment	-Change in numbers and percent employed, unemployed, under-employed, by skill level	-Labour force participation rates by age, sex -Number of households with both parents working
	-Number of new long-term and short-term jobs provided	-Percentage of new jobs going to "locals" -Average wage rates of new jobs
3. Wealth	-Change in land values	
C. PUBLIC AND PRIVATE SERVICES		
1. Drinking water	-Change in frequency, duration and severity of water shortage incidents, and number of people affected	-Change in likelihood of increased water shortages, and number of people likely to be affected
	-Change in salinity, and other indices of drinking water quality and safety, and number of people affected	-Changes in effluents or purification processing likely to affect taste or other qualities of drinking water
2. Hospital care	-Change in number of citizens beyond x minutes travel time from emergency health care	-Average travel time to nearest hospital -Maximum travel time to nearest hospital -Number of ambulances per capita
	-Change in average number of days of waiting time for hospital admittance for elective surgery	-Average waiting time for emergency treatment -Number of doctors per capita in market area
3. Crime control	-Change in the rate of crime in existing community	-Expert rating of change in crime hazard -Number of particular crimes -Number of policemen per capita

Table 9-1 Continued

Class	Indices	Other variables where appropriate, measured as changes
3. Crime control (continued)	-Change in percent of people feeling a lack of security from crime	-Personal expenditures for protection
4. Fire protection	-Change in fire incidence, property loss and casualty rates	-Expert rating of change in likelihood of fires, fire spread, rescue hazards -Number of major fires -Number of firemen per capita -Fire insurance rates
5. Recreation	-Change in number and percent of households satisfied with public recreation opportunities	-Comparative rating of this area *versus* others
	-Change in number or percent of households using facilities, (viewed relative to nominal capacity), by facility	-Average participation rates -Frequency of visits, length of stay
	-Change in number and percent of households with access to various types of recreation facilities within x minutes of travel, by type of facility and mode of travel	-Average travel time to facilities by type -Maximum travel time to facilities by type
6. Education	-Change in number and percent of students within x minutes, by type of school and travel mode	-Average travel time, maximum travel time -Average number of major streets crossed in walking to school
	Number and percent of students having to switch schools or busing status (from walking to busing or *vice versa*)	-Number of students affected by altered school regions -Change in location of schools, and physical conditions around schools or along routes to school that are likely to affect satisfaction with accessibility
	-Change in school crowdedness indicators e.g. student-teacher ratios, number of shifts	-Number of programs added or deleted -Number of students not accommodated in first choice programs -Number of major discipline occasions -Changes in standard test score averages
7. Local transportation	-Change in vehicular travel times between selected origins and destinations, by time of day and day of week	-Public transit and pedestrian average travel times between selected origins and destinations
	-Change in duration and severity of congestion by mode	-Number of bottleneck intersections

Table 9-1 Continued

Class	Indices	Other variables where appropriate, measured as changes
7. Local transportation (continued)	-Change in average time needed to find acceptable parking space within x metres of residence (or desired destinations) in neighbourhood, by time of day and day of week	-Demand for parking spaces -Supply of parking spaces
	-Change in numbers and percent of residents with access to public transit within x metres of their residence; and numbers and percent of employees who can get within x metres distance of work location by public transport	-Rate of transit ridership -Number of transit riders -Probability of obtaining a seat in rush-hour
	-Change in the rate of traffic accidents	-Expert rating of change in hazard -Number of serious personal injury accidents
	-Change in number and percent of households satisfied with traffic safety, and with walking conditions and opportunities in their neighbourhood	-Change in physical conditions (sidewalks, noise, etc.) affecting current satisfaction or dissatisfaction with traffic safety or walking conditions, and number of households likely to be affected
8. Shopping	-Change in number and percent of households within x minutes travel time to shopping, by type of store and mode of travel	-Average distance to nearest grocery store -Average distance to nearest drug store -Average number of parking spaces per store
	-Change in number and percent of households satisfied with local shopping opportunities	-Average number of family shopping trips outside local area -Number of retail establishments changing function
D. HOUSING AND SOCIAL CONDITIONS		
1. Housing adequacy	-Change in number and percent of housing units that are substandard and the number and percent of people living in them	-Average number of rooms per person -Average number of persons per toilet

Table 9-1 Continued

Class	Indices	Other variables where appropriate, measured as changes
1. Housing adequacy (continued)	-Change in number and percent of housing units relative to need by type of housing (price, owner/rental, number of bedrooms, style, etc.)	-Number, rate of demolition and new construction -Number of rooming houses -Average amount of private green space per housing unit
2. People displacement	-Number of residents or workers, displaced by development and whether they are satisfied with having to move	-Percentage of displaced residents able to find similar, or suitable housing -History of turnover in displaced units
3. Population mix	-Change in population distribution by age, income, religion, racial or ethnic group, occupational class, and household type	-An index of spatial segregation of various types of groups
4. Crowdedness	-Change in percent of people who perceive their neighbourhood as too crowded	-Residential density -Average number of persons per household
5. Sociability-friendliness	-Change in social interaction patterns (e.g. frequency of neighbourhood visits, community activities)	-Average number of acquaintances in neighbourhood -Number of sidewalk conversations
	-Change in percent of people perceiving the neighbourhood as friendly	-Number, frequency and size of neighbourhood social events -Participation rates in local social groups
6. Privacy	-Change in number and percent of households satisfied with privacy in and around their homes	-Change in sightlines, pedestrian volumes, or other conditions likely to affect satisfaction, and number of households potentially affected
E. AESTHETICS AND CULTURAL VALUES		
1. Attractiveness	-Change in number and percent of citizens who are satisfied with neighbourhood appearance	-Disturbance of physical conditions currently considered attractive; removal/improvement of conditions currently rated unattractive
2. View opportunities	-Change in number and percent of citizens satisfied with views from their homes (or businesses)	-Number of households (or businesses) whose views are blocked, degraded or improved

Table 9-1 Continued

Class	Indices	Other variables where appropriate, measured as changes
3. Landmarks	-Rarity of landmark and distance to nearest similar examples of landmarks to be lost or made more accessible	-Number of formal and informal visitors annually -Average frequency of visits by local residents
F. OVERALL CONTENTMENT		
1. Overall contentment with neighbourhood	-Change in percent of people who perceive their community as a good place to live	-Difference in average length of time it takes to list 5 good, and 5 bad things about neighbourhood -Percent of household heads who report they would move out of neighbourhood if given $10,000.00.
2. Fairness to all groups	-The above indices should be considered with respect to specific clientele groups or population segments that are affected to reflect the quality of fairness in new developments	-Percentage of citizens who think that the net effects of the project will not be fairly distributed -Number of man-hours expended in demonstrations

Table adapted from Schaenman and Muller (1974) and Schaenman (1976)
The last column and several other items are original to the present authors.

The problem of obtaining quantitative measures of variables is particularly acute when it comes to socio-economic variables. For example, even if it were possible to define clearly what is meant by "community cohesion", it is next to impossible to measure this attribute meaningfully or validly at a high level. An example of "a high level of measurement" would be a measure of government fiscal revenues in dollars - i.e. something concrete to which we could add meaningful decimals and the value 8 is known to be twice as large as 4. This high level of measurement is referred to as an interval or ratio scale. There are two lower levels of measurement: the ordinal - in which we can simply "rank order" values but we cannot say how much higher one value is than another; and the nominal - in which we can only put things in categories, such as (male, female) or (house, condominium, apartment). In socio-economic analysis often we can only attain these lower measurement levels. This poses significant problems for comparisons, for adding up, and for assessment of change over time. It is not meaningful, for example, to add ranks nor to find the average rank, whereas these are entirely valid ways of dealing with high level measurements. The final chapter about how to write up a report focusses on the presentation of high level measurements. Simple statistics, described in Chapter 10, such as the mean and the standard deviation, cannot be used in conjunction with many socio-economic variables because of their low level measurement. Without a guiding theory, the variables selected, the way in which they are measured, and the forecasting of changes in them should be based on clear, intuitive reasoning and common sense. For example, it would be unwise to add up all local crimes (theft, break-ins, murders, etc.) as an index of neighbourhood security.

The evaluation phase, as was pointed out in Chapter 6, is also extremely problematical. We must be able to say how people value less traffic congestion, more crowded schools, more accidents, a more aesthetically pleasing environment, and so on. In fact, not only must we deal with the social evaluation of direct social and economic effects but we must also deal with the *social* evaluation of effects which are not directly social or economic - for example, decreased variety

of birds, animals and trees. There must be a very strong value judgement made in order to say that society would favour a situation in which 5 minutes is saved on the average intra-urban trip but that there are 4 more traffic deaths annually and one less ravine, or a situation in which a hectare of semi-natural ravine land is destroyed for the construction of an apartment building accommodating 400 persons. If an EIA statement or planning document makes any *recommendations* at all, then a strong judgement about what people prefer and how different people's preferences are to be weighted must have been made. Unfortunately, the norms which are used are typically hidden and not made explicit. Existing welfare theory does not provide a basis for the value-laden judgement that society prefers the saving of 5 travel minutes per capita to 4 lives. Indeed, the whole problem of "evaluation" is exacerbated by the likelihood that any particular project, including doing nothing, will make some group(s) in society better off but make some other group(s) in society worse off. As there are no right answers to these value-based questions in the paradigm of science, such decisions are, and should be, left to the realm of politics. The planning process should be as objective as possible in its predictions of effects or changes. But, to the extent that evaluation is performed, there must be a clear explanation and justification for the subjective value judgements which *must have been included*. The problem of judgements often appears to be solved by surveying the public and/or holding a public hearing.

In the discussion which follows the prediction and evaluation of socio-economic effects are dealt with separately. The discussion of approaches to prediction distinguishes between variables that are capable of high levels of measurement and those that are only capable of low levels of measurement. The discussion with respect to evaluation focusses on two particular commonly used approaches - cost-benefit analysis and social impact assessment. An exemplary problem is outlined first, however, and is used throughout to illustrate the discussion of both prediction and evaluation.

AN EXEMPLARY PROBLEM

It will be useful for what follows to have an illustrative reference problem. The following entirely hypothetical problem embraces a wide variety of issues to which we can subsequently refer.

Imagine that a private land development firm has proposed building an apartment complex on land which it owns. The land is in an accessible part of a major ravine bordering on a middle-income residential neighbourhood. The site is forested, of mixed relief, subject to occasional flooding, the habitat for many species of wildlife not usually found in urban areas. The land has a walking and bicycling path through it and is used by the public for passive recreational purposes and by the Society for Crippled Children as its site for a summer day camp. The proposed apartment complex is to be largely subsidized low income housing for inner city residents.

Before proceeding, it is useful to point out the difficulty faced by the assessors in selecting alternative projects. Of course, leaving the land as it is - the "no-go" alternative - must be included. There are two different bases for selecting other alternatives. The first, and most obvious, is other uses for this parcel of land. For example, the apartments could be for non-subsidized households; there could be single family housing; there could be a formal park; or a permanent camp site; etc. In order to bound the tremendous variety of alternatives, assessors usually only consider those which have been seriously suggested by community groups, politicians, etc., and which are deemed to be technically feasible and do not contravene zoning by-laws or official plans. The second, and less obvious type of alternative, is based on recognition that the project addresses the need for low income housing and that an alternative way of meeting this need would be: (a) to construct a similar project on another available (and perhaps more suitable) site; (b) to subsidize the needy directly in various ways so that they could participate in the normal "housing market". Again, alternatives are typically restricted by a survey of those which have been suggested. Groups who are fundamentally opposed to such development of urban "natural areas" must develop compelling counter-proposals (in both senses noted above) very early in the planning process. The alternatives

which should be included, according to welfare theory, are those which are suspected of better meeting the objectives of the project, (or more generally, the goals of society), than the proposed project itself. Great care must be given to the process of defining the objectives of the project, so that meaningful and feasible alternative ways of meeting the objectives can be invented and evaluated.

9.3 PROFILING AND PREDICTION OF SOCIO-ECONOMIC VARIABLES

In order to evaluate change, we must be able to predict change. In particular, we must determine the current levels of key variables, and we must predict the future levels of key variables with the project, without the project, and with other judiciously selected alternatives. All variables likely to be affected by the project or alternatives constitute key variables. The problems of variable selection is addressed in section 9.4 as well.

Prediction is one of the principal goals of science. The first step towards prediction is to find, or formulate, relevant theory. Theory is especially required in situations in which there is great complexity and a high level of interdependency and interaction among the variables of interest.

The list of indices and variables in Table 9-1 highlights that the socio-economic system in an urban area is exceedingly complex and highly interrelated. Predicting the change in one variable is not possible without taking account of the causal and derivative changes in other variables. Compared with theories in the physical and biological sciences, those in the social sciences are scarce and weak. The models which tend to be used are highly simplified conceptions of real world socio-economic systems. The approaches to predicting economic and high level of measurement social variables on the one hand, and other less "quantifiable" variables on the other, are taken up separately in the discussion which follows.

HIGH LEVEL OF MEASUREMENT VARIABLES AND THEIR PREDICTION

In this section we will discuss four exemplary approaches to predicting economic and high level of measurement social variables (e.g. indices A1, B1 and B2 in Table 9-1). The first, "input-output analysis", serves to illustrate how interdependent economic systems are often modelled. The second, cohort survival models, illustrates how population change is usually predicted. Regression analysis is the third: it is used to illustrate how statistical analysis can be used in forecasting. The fourth, "analogy" acknowledges the possibility of making tentative predictions with very little theory indeed. A secondary purpose of this section is to present a few examples of important urban socio-economic processes which must be addressed, in one way or another, in any urban impact assessment.

Input-output analysis

Input-output analysis has been widely used to model national economies. Recently, however, the technique has been adapted to, and used successfully on, urban economies. See, for example, Morrison and Smith (1977). Imagine that we have been able to divide the local economy into a set of useful sectors, or groups of industries, for example: construction, manufacturing, retailing, private services, public services, education, etc., and finally households. Each industry buys goods and/or services, from, and sells them to other industries. For example, households purchase goods and services, consume education, and supply labour. We now set up a table, or matrix, with each of these industries as both rows and columns. Data are then found on the dollar value of transactions between each industry and all others in the existing economy. This table is then subject to minor manipulation to produce a matrix of input-output coefficients which show the breakdown of one dollar's worth of output into fractions of one dollar's worth of various inputs. It is this table which captures the interdependencies in the economy. Further straightforward manipulation yields a set of equations in which we have the level of output of each industry as a function of the level of "final demand" for each industry's product.

These equations are typically used in the following way. Most projects will change one or more levels of final demand. For example, our project will certainly

increase the demand for construction, the demand for services, for education, etc. in fairly predictable ways. The new values of demand are then "plugged in" to see how the output of each industry will (must) change if the final demand is to be satisfied. Monetary values must then be placed on the increase in the outputs which constitute the "impacts" (valued effects) of the project. The reader may well reason that such a model is entirely unnecessary. The increase in construction jobs can be valued as the increased wage bill, the increase in retail purchases can be directly valued, and so on. But this is not so. New construction jobs give rise to increased retail purchases, increased service need, increased need for class-room space, etc. Increased retail purchases require a larger number of retail clerks, increased manufacturing and manufacturing jobs, and so on. The lesson here is that for every change in final demand in the economy, there will be a long series of reverberations throughout the economy, not only in the sector of direct impact but in all (or most) others, too. The input-output model captures all of these reverberations in a theoretically rigorous way. It is normally assumed that the system returns to "equilibrium" fairly quickly; it is not capable of directly dealing with other changes from outside - for example, new government budgets, etc.

Thus input-output analysis is capable of fairly accurately predicting the total economic effects of a change in demand by accounting for all of the indirect and induced effects. There are two interesting problems - bounding the study area, and obtaining or estimating the transaction table. If the study area is taken only as the local community, it is clear that many of the indirect effects (often benefits) will occur outside this area. For example, the increased spending by construction workers will largely take place where they live. There is an important lesson here: there is no reason, save convenience, for considering only costs and benefits at the local community or immediate impact area. After all, we should be addressing the issue of welfare to all of society. It is possible to structure input-output models so that they deal with more than one region; thus we can obtain estimates for local effects and effects on the rest of the urban area. The real difficulty in using input-output analysis at small scales is obtaining the relevant data. Surveys are expensive and many of the procedures which have been developed for adjusting national and provincial input-output tables for use at the local level are theoretically weak.

Cohort survival methods

Cohort survival models are designed to forecast future population distributions by age (cohort) group, sex, and in some cases, other variables. Like input-output models, they work with flows between cells of a matrix. Imagine that by studying census data we are able to determine the percentage of individuals in each 5-year cohort (e.g. aged 6-10 years) who survive to the next 5-year cohort group (here 11-15 years) at the end of 5 years. We can also easily discover the number of births and the birth rate by age of mother. In the absence of migration in or out of a region, and assuming nothing significant happens in the way of epidemics or medical breakthroughs, we can use the birth rates and survival ratios to forecast the population size, by cohort, 15, 30, or 50 years hence. This simple cohort survival model can be made much more elaborate.

In particular, in forecasting population change in small areas, we must take migration into account. At the simplest level, we would deal with net in-migration; at more sophisticated levels, we can have a full multiregional model. In our case study, we would have to forecast normal population change under the no-go alternative and for this we would probably be satisfied with an estimate of migration based on the most recent migration data. To see the direct population implications of the project we would have to estimate the age, sex, and period of arrival of the new residents and enter this systematically into the model. If the birth rates and survival attributes of the new group are significantly different from the existing group, we would want to take this into account. Also, the new, low-income arrivals may have an effect on the rate of out-migration and we would want to estimate this indirect effect.

These cohort survival-type models are a well-developed and powerful set of tools for coping directly with fairly well-understood processes of population dynamics. See Glenn (1977) for a more elaborate description of these models. If the models themselves are not used, then the ideas contained in them should be drawn upon. The weak links will be obtaining detailed and up-to-date population data which pertain to the area of interest and in forecasting future migration. Indeed,

there is a separate body of literature and set of models which address the problem of migration but they are usually not well adapted to small area problems precisely because individual household movement decisions are not well understood.

Regression analysis

The input-output model is entirely deterministic - that is, probability and statistics are not involved. Cohort survival models are slightly probabilistic in that we normally speak of the probabilities of surviving from one cohort to the next. However, for both, the processes are reasonably well understood and set out in theory. For many socio-economic variables, for example, crime rates, number of fires, passive recreation participation rates, for which there is no well developed theory, one way of proceeding is to first develop a simple form of (statistical) empiricism and then use this to forecast future levels. The statistical technique known as regression analysis is ideally suited to the task when suitable data can be found or collected. In fact, suitable "regression equations" for prediction may already be available in the literature or from public agencies (fire and police departments, hospitals). To illustrate the idea of regression we will deal with the case of predicting recreational use of the ravine land adjacent to the proposed development.

We will start with the simplest possible model. It is intuitively clear that the number of people who live within easy walking distance of the ravine will very likely vary directly with the number of people who live within easy walking distance of the ravine; we will use 500 m for convenience. In order to use regression, data are required on two types of variables - the variable to be predicted and the variable which will serve as the predictor. In the present case, the former is the number of ravine users on an average day and the latter is the number of people living within 500 m of the ravine. The next step would be to select a sample of 10 or so ravine sites around the urban area which are similar (in the sense of type of setting and available facilities) to our area of interest. For each sample area, data must then be collected. Data on number of ravine users, U, per day would require a field survey, whereas the population in the area, P, can be estimated by counting houses on a large scale map and multiplying by the average number of people per house (from the census). Standard statistical manipulation will allow the formation of the following linear equation which indicates the number of ravine users per day as a function of the total accessible population.

$$U = a + bP$$

a and b are the intercept and slope of the "regression line" respectively. A "b" value of 0.08 would indicate that for every increase in population by 100, the number of users would increase by 8. Note that in order to develop such an equation one must have enough data to be able reliably to estimate the parameters - the a and b values. In order to predict the presumably larger number of ravine users we would simply have to plug into the equation the new value of P (accessible population) after the project has been built. Regression equations like this are only helpful in prediction if the following three conditions are met. First, there must be a strong relationship between the two variables (here U and P) and this may be easily assessed using statistical theory. Second, it must be argued that the processes at work in structuring the data we collected (say, for last year) will be the same processes at work next year or 5 years hence. (However, if there are temporal trends in passive ravine use, we can restructure the regression equation to deal with these.) Finally, and most obviously, the variable, here P, we are using to predict the U must be much more reliably predicted than the U itself; otherwise we will be no further ahead as the value of P would then have to be predicted in the same way using another variable.

Typically, socio-economic variables cannot be "explained" by relating them to only one other variable. For example, land values cannot be explained with one variable. We must use several variables and multiple regression analysis of the form: $U = a + b_1P + b_2X + b_3Y + b_4Z$, etc., where X,Y and Z are other variables which we believe will help explain and predict U. In the present case, for the number of ravine users, the following additional variables could be considered. The proportion of the accessible population which are children may help, because children may be

heavy users. The average amount of yard space per capita may help because participation rates would tend to increase in areas of apartments and small backyards. The number of alternative reasonably accessible parks, ravines, etc. (intervening opportunities) would help because use of one location would tend to decrease as the number of alternative locations increases. Note that none of these variables relates to the attributes of the ravine. If we are interested in predicting the effects on users of changing the attributes of the ravine (cycling path, walking trail, etc.) then we should include as predictors, variables which represent these dimensions of the problem. The best predictor variables are those which are directly affected by the project.

Regression analysis is a tool which has been very commonly used in the social sciences. Not only is there a well-developed body of statistical theory underpinning regression but computer programs for doing all the work are almost universially available. The interested reader is referred to Blalock (1979) for a discussion of the uses and statistical basis of regression analysis, and to the SPSS computer package developed by Nie *et al.* (1975) which represents the most generally available set of computer programs for regression analysis. There are two commonly cited reasons why regression analysis has not been as widely used in impact assessment as it should be. Often it is claimed that insufficient data were available. Most of the time this is simply not true; if assessors expect all data to be provided in suitable form without searching and field work, etc., then there is little sense in doing impact assessments. The excuse for insufficient time, budget and/or expertise is also a common one. All studies have such constraints. The decision not to make a serious attempt to predict an important socio-economic variable should usually be simply taken as evidence that a value judgement has been made to use limited research resources in other ways. A very damaging criticism of any impact assessment is the demonstration that a relatively simple and inexpensive predictive model could have been used. It is especially damaging to implement such a model and to show that its results do not substantiate a guess based on *ad hoc* methods.

The use of analogous situations

All three methods of prediction noted above are formalized quantitative techniques. For a variety of valid reasons (including a genuine lack of data, an inability to measure all the required variables at a high level, etc.) it may not be possible to use these methods of prediction for particular variables. One of the most straightforward ways of proceeding under these conditions is to find and make use of the impacts attributable to a similar project and situation elsewhere. The goal is to find a project which is as similar as possible to the present proposal and which was actually implemented in the recent past. Ideally the time of implementation would be far enough in the past that most of the impacts would have worked themselves out by now, but not so far in the past, or so far removed spatially from the proposed project, that the criticism could be made that what happened then and there has no connection with the present project. For example, for our case problem, we would search for a low income apartment which was constructed say 3 to 5 years before on the edge of a ravine in a middle class residential district. If it is not possible to find a "low income" apartment, we can still get a reasonable idea of many of the expected impacts by studying the impacts of a regular apartment. The ravine site would, however, be less dispensible.

The objective of finding such an analogous situation is first to discover the impacts of that project and second to justify the reasoning that those same impacts are likely to be forthcoming with the proposed project. The theory is simply that the processes at work, including peoples behaviour, etc., do not change dramatically over time or through space - so that what happened before will happen again. Note that in studying the analogous project we are still faced with the problem of determining which changes in socio-economic variables are attributable to the project and which are due to other causes. A good way of doing this is to match the analogous project with a benchmark ravine area which was not developed. Unlike the other prediction methods discussed above, analogy may be used to suggest changes in variables which are not easily measurable at a high level - for example, "neighbourhood cohesion", "neighbourhood aesthetics", etc.

It should be clear that if a good analogy can be found, then a good deal of insight may be gained. However, it is equally clear that basing predictions on analogy, particularly tenuous ones, can be soundly criticized. Nevertheless, it is likely that the credibility of predictions based on good analogies is much higher than the subjective judgements of assessors using *ad hoc* approaches. It is surprising, therefore, how seldom analogies are used in comparison with *ad hoc* approaches.

LOW LEVEL OF MEASUREMENT VARIABLES AND THEIR PREDICTION

Stress has been placed in the discussion above on the prediction of changes in variables which are measurable at a high level and for which it may be reasonable to asign monetary values to evaluate the predicted changes. The variables with these attributes tend to be those which are appropriately called economic or demographic. Many social and cultural variables, if measurable at all, are only measurable at a low level. A way must be found of dealing with these variables.

It is helpful, at the outset, to provide a rough idea of the kinds of "social" impacts that would normally be treated. The different subject matters and perspectives of at least four different social science disciplines should ideally be embraced: sociology; social psychology; anthropology; and political science. Thus, one would expect to see discussion of effects on individuals, families, groups and organizations, neighbourhoods, the community, various institutions, culture and politics. The questions asked should, therefore, range over, but not be restricted to, the following. How will individuals perceive and react to the changes brought about? Will they have an enlarged or a reduced choice of activities, more or less free time? Will they feel more involved in decisions and in the community generally? Will they feel better or worse off? Will the institution of the family be affected and, if so, how? Will the size, composition, objectives and actions of community groups, organizations and clubs be changed and, if so, how? Will some organizations die and others be formed? Will participation in organized religion be influenced? Will there be reduced polarization between opposing interest groups? Will the ethnic character and culture of the community become more, or less, homogeneous? Will neighbourhood or community identity, spirit, and cohesiveness be diluted or reinforced? Will community leadership be affected? Will political institutions be altered? Will political participation be increased? more focussed on fewer issues? more polarized? It is clear that these and similar questions must be both asked and answered from the point of view from those people, groups, and neighbourhoods most affected by the project.

In Table 9-1 we have provided an exemplary list of the classes of socio-economic impacts that are normally examined in the socio-economic chapters of EIA reports and similar planning documents. Many of the questions set out above are not represented. For example, whereas under D and E the issues of sociability, friendliness, privacy, ethnicity, crowdedness and attractiveness of community are addressed, there are no variables representing impacts on community groups and institutions, nor interactions between these and other variables. Indeed, it is very unusual to see any impact assessments deal as they should with the whole range of questions posed above. Of course, in any particular project, especially a fairly small one, it should not be necessary to deal with all these areas. Unfortunately, however, there has been a bias toward including in the study only those variables which are easily measured at a fairly high level; for example, most of the ones included in Table 9-1 are of this type.

It should be noted that, whereas the largest economic and demographic effects tend to be direct ones (for example, directly due to the project, to the people who move in, etc.), the largest and most important social and cultural impacts are more likely to be indirect effects. For example, one of the impacts of the case project noted above may be increased pressure by local service organizations on local politicians to make ravine lands freely available to summer day camps like that of the Society for Crippled Children. Another may be a larger juvenile division in the local police force, at the expense of other important divisions. It also could be remarked that most social effects will be concentrated in a smaller area than most economic costs and benefits, although exceptions may certainly be found.

Predicting most social impacts is more of an art than a science. As has been noted, the problem really boils down to a lack of theory. The task is made a little less problematic if agreement is first reached on a set of *meaningful social indices* of the type listed in Table 9-1. Clear definitions (in the form of proxies or indicators) of what is being predicted saves a great deal of time and anguish. A wide range of prediction methods have been discussed in the literature. (see, for example, Miller 1977; Hausmann 1979). In the following rather superficial overview only four exemplary approaches to the prediction of low level measurement (social) variables will be discussed. Two approaches, regression analysis and the use of analogous situations are dealt with together. In the experience of the present authors, the methods wich have been used most frequently are *ad hoc* non-methods of sheer guesswork analysis. Nothing can be said about these, except that they provide excellent grist for the critics mill.

Regression analysis and the use of analogous situations

The methods of regression and analogy, noted previously, may be used to forecast changes in social variables and are particularly suitable for those cases in which it is possible to use a high level social indicator. However, both methods depend on having data relating to the impacts of other similar projects. Unfortunately, these data are seldom directly available and are very difficult to collect *ex post*.

Expert judgements

One common approach to forecasting in situations of little or no theory, great complexity, and uncertainty is to ask "experts". The first task is to assemble a group of experts who are familiar, or who are made familiar, with the project and the society it is likely to impact. They may include sociologists, social psychologists, anthropologists, political scientists, and others. They are asked to predict certain social effects of the project - be they direct or indirect. If the experts do not agree, then one of two courses of action commonly is pursued. The first is to take the average or median prediction. The second it to try to secure greater agreement (ideally unanimity) by implementing what is called the Delphi method. In this method, the group is shown the average response (and perhaps the range in responses) to the questions at issue and each participant is asked to consider revising his or her predictions in light of what others have predicted. This can be done in a meeting or via a questionnaire. It can involve discussion before revisions are asked for, or no discussion. Experience has demonstrated that on many types of issues and questions, a substantial convergence of opinion (prediction) can be achieved. The final prediction is usually taken as the median view.

Judgements of community members

Other social impact assessment researchers feel that for many social variables - especially those which call for a judgement about how the community feels or will evaluate the change - "community leaders" should be interviewed or asked to participate in a Delphi-type exercise. A single group of community leaders could be used for a wide range of variables or several group leaders could be selected especially for each key variable. They could comprise political leaders, business leaders, union leaders, presidents of organizations and service clubs, directors of political bureaux, leaders of local interest groups and/or simply prominent citizens. One way of selecting these "community leaders" is to conduct a sample survey of local residents (which is often undertaken for other reasons - more below) and simply ask them to list five or so community leaders; the most frequently listed names would then be invited to participate. Research has demonstrated that if community leaders have been judiciously selected, their views about what the impacts will be are a fairly accurate picture of what the average members of the community at large think they will be.

Finally, it may be argued that the best people to ask would be a random sample of community members likely to be impacted. This could be done by questionnaire, telephone interview, or face-to-face interview. This view is difficult to sustain if the variables to be predicted are highly technical or complex ones. A better case can be made for involving the public directly when the variables at issue are highly subjective and intuitive; for example, the effects on community culture, friendliness, and so on. In such cases the public should normally be asked to both predict and evaluate the effects.

9.4 EVALUATION OF SOCIO-ECONOMIC VARIABLES

In environmental impact assessment, many of the variables of interest are not value-laden *a priori*. For example, we may *predict* that the long run population change will be am increase of 1,000 residents, or a loss of 1,000 seagulls. The social *evaluation* of these changes may range from highly desirable to disastrous, depending on who is asked. When social variables are at issue it is very often difficult to distinguish between prediction and evaluation. This is partly due to intrinsic properties of such variables but also partly because of the way the variables are labelled. For example, friendliness, attractiveness, neighbourhood cohesion are clearly such that all reasonable people would evaluate a positive change in these as desirable changes. To some extent, then, prediction of the effects of the project on such variables is an evaluation.

However, it is always wise to bear in mind that the real objective of most EIA's is to *predict the community's evaluation* of predicted effects. Thus, for example, we want to know not only that, say, 60% of the community think that community "attractiveness" or "cohesion" will be adversely affected, but also whether society (the community) thinks these are critical, important or unimportant changes. Two approaches to evaluation will be reviewed here. The first, cost-benefit analysis, henceforth CBA, copes with the issue of value, or relative importance, by reducing all variables to a common unit of value - dollars. Most people think that it is infeasible and/or unwise to reduce all social-type impacts to this unit of value. This criticism has provided a major stimulus for the development of social impact assessment, henceforth SIA, the second approach that will be reviewed here. In cases where this approach is used and evaluation is required (and it usually is), the SIA analyst is put in the unenviable position of having to discover the appropriate "weights" to attach to the different dimensions of the social realm - a task normally considered to be reserved for duly elected politicians.

COST-BENEFIT ANALYSIS

By far the most common approach to evaluating the socio-economic impacts of proposed projects has been cost-benefit analysis. This is the only approach that is based on a well-articulated theory - in particular, the welfare economic theory. A description of the key features, and problems of CBA is a direct way of getting at some of the essential components of a good evaluation of socio-economic impacts. Although conceptually very simple, CBA is a very powerful and sophisticated tool with many tricks and subtleties to lead the unwary astray. Only a few of these will be discussed here. The interested reader will find a number of helpful references at the end of the chapter - especially the manual put out by the Canadian Treausry Board in 1976. It should also be noted at the outset that CBA has come under considerable attack in recent years for a variety of good, and misguided, reasons. One valid criticism is the inability of the approach to deal effectively with variables which are not measurable at a high level and easily expressed in monetary units. Whereas most "economic variables" have tended to be fairly easily measured and monetarized, most "social variables" are not. The CBA's then tend to deal with these latter variables in a non-systematic or contentious manner, or to omit them entirely. Thus, the present discussion will lead quite nicely into a discussion of ways that social variables can be integrated or treated differently.

The conceptual framework

In making investment decisions, for example a new plant, private firms estimate the construction costs and operating costs and then forecast the revenues (benefits) they will derive from selling the product. Because one dollar in costs or revenues in the future is considered to be worth less than one dollar today, all future costs and revenues are "discounted" at the prevailing interest rate, to "present value" terms. (This process of discounting is the exact converse of computing the future value of a dollar invested today using the formula for compound interest.) Future costs and benefits are discounted so they are in commensurate units (present dollars) in order that they may be compared. In particular, the firm would seek that investment which maximizes its net worth. Note that in considering costs and benefits, the firm would only consider those costs and benefits which pertain to it directly. For example, it would not include the costs imposed on others by smoke from its chimneys, or the secondary impacts on the community of increased employment.

Cost-benefit analysis is based on the same principle of comparing the present values of costs and benefits. The difference is that *all costs and benefits to society as a whole now and in the future should be included and handled in the same way*. Normally with projects, most of the costs are incurred early in the project, whereas most of the benefits are spread over many years. Also, the major direct costs are relatively easily expressed in dollar terms whereas the dollar value of many benefits must be estimated indirectly. Economic theory is used to impute the values of costs and benefits which are not directly available in dollar terms. For example, the benefits derived by walkers and cyclists in the "no-go" alternative, in the exemplary problem outlined earlier, would have to be estimated from some inferences drawn about their "willingness to pay" for their recreational use of the land. Some imputations are often very tricky and are, of necessity, based on simplifying assumptions which may be quite unrealistic.

It should be stressed that CBA is an *evaluation method* based on reducing effects to a common unit - current dollars. The method does not address the issue of how to forecast the effects or the changes in key variables in the first place. (Indeed, all environmental impacts assessment "methods" are evaluation methods; none of them address the problem of prediction.) The approaches to prediction which are commonly relied upon were reviewed earlier in this chapter, and these must be used to forecast the effects or changes in key variables. The CBA has been criticized because it uses dollars to measure all costs and benefits. On the other hand, this can be viewed as a forte. If the goal is to arrive at some fairly objective bottom line summary figure on which to base action, *some common unit of value must be used*. Standard loaves of bread, human lives, ergs of energy, or some other invariant unit could be used. However, dollars are much more commonly used and understood. There is also a well-developed body of theory in economics on which we can draw in assigning dollar values to a wide variety of variables, including many which might be considered to be more social than economic.

The selection of variables and assigning of monetary values

The rule used to select the variables to be included in the study is very simple: include all variables which are affected by the project or alternatives. In practice, the number of variables to be examined is reduced substantially by considering only those for which there will be a "significant change" and only those affected differentially by the alternatives under study. Because it is not feasible to predict the change in every conceivable variable in order to discover those which had a significant change, the wisdom of the assessors is applied in creating a "short list". The adjective "significant" should be taken in the sense of social significance. It is possible that a large change in a variable might have little social significance. For example, in our sample problem, the number of people using the local buses may increase dramatically - but this is not very significant if the bus system has considerable excess capacity. On the other hand, a small change in a variable might have great social significance. For example, among the trees to be cut down (a small percentage of the total forest), there may be several 300 year-old oaks and mature walnut trees which have been local landmarks for years.

Any thoughtful reader of most CBA's and impact assessments should be able to find key variables that have been left out of the study.

The simplest variables to value are goods and services provided through competitive market processes. The value is deemed to be equal to the price and total value is price times quantity sold. This is only really valid when the change in supply is relatively small (marginal) and there is no element of monopoly or externalities. If either of the latter is present, one should modify the market prices. If there is a significant change in supply, the notion of "consumer surplus" should be used to assign values. The logic of this concept is quite simple. The surplus associated with each unit of a good or service is the difference between the price that is in fact paid and the price that a person would be willing to pay (which is typically greater than the price actually paid). In order to do this, one needs to estimate individual "demand curves". For many goods and services, especially those not provided through market process, this is often a difficult task.

Those costs and benefits related to the project which are not directly tied to market processes must be "imputed". Benefits are monetized by trying to answer the question - what would the beneficiaries be willing to pay (if it were possible to charge them)? For example, in our hypothetical case study, it would be necessary to monetarize the benefits of those using the land parcel for passive recreation. Usually, this estimation is carried out by examining the accessible alternatives available for each activity (e.g. cycling in the woods) and trying to determine the additional costs that individuals would bear to use these alternatives. This additional cost is often imputed to be the extra time to get there (valued at the hourly wage rate). It is clear that many assumptions must be made in order to proceed. Often values are determined by examining the prices that similar goods and services sell for in the market place. For example, in valuing the benefits to the crippled children's camp, from free use of the site, one approach would be to use the rent paid by similar camps in other portions of the ravine system (perhaps even in another city). The value of the housing to the low income families should be valued at more than the subsidized rent levels; rather we would use the market price (rent) of similar-sized units in the area. Prices which are used to estimate the true value of certain goods and services are generally called "shadow prices". There are some very powerful methods for estimating these shadow prices but they require considerable data and analytical expertise to operationalize.

Although the proponent of the project clearly incurs more of the cost, there are often many "external costs" borne by members of the community which must be estimated. The costs of increased vandalism in the community (if any) could be valued at the repair and replacement costs of property vandalized. However, the social cost of the loss of the mature oak and walnut trees would be much more difficult and would have to be based on the value placed on similar trees elsewhere in the city or on an estimate of the community's willingness to pay for the right to have these trees preserved.

The estimation of the monetary values is one of the trickiest parts of a CBA. Usually a careful reading of a CBA will reveal a number of rather peculiar and far-fetched assumptions or procedures. One of the most common flaws of hastily prepared CBA's is the double counting of costs or benefits; this can severely distort the results. For example, let us assume that we have been able to estimate the costs due to increased vandalism and crime in the neighbourhood and the social costs of loss of forest and the reduction in land values around the project. It would not be legitimate to simply add these up as components of total costs. This is because land values are predicted to fall in part *because* of these other increased social costs. Social costs and benefits are capitalized into land values - but seldom perfectly. Land value change should either be omitted from consideration or else a case should be made that land value change alone gives a good indication of net social benefit. Another common fault is including costs or benefits which are costs to one group and benefits to another. For example, it is common to see it argued that increased sales by local retailers are a benefit of the project. However, if the families have moved here from downtown, presumably the merchants there lost the business gained here. It is clear that if the impact area is defined to be very small that distortions of this kind will be much more common. It should be remarked that defining the impact area as a very small area is an error which tends to increase the benefits artificially of all land development projects.

The discount rate and decision rules

It has been noted that, for most projects, the stream of benefits continues much longer than the bulk of the costs. This means that if future costs and benefits are discounted at a very high discount rate, this will significantly reduce the present value of benefits vis-à-vis costs. On the other hand, if a low rate is used, the present value of benefits will be substantially increased. The choice of the discount rate is, therefore, very important. Related to the issue of discount rate is the "life of the project" which is typically set between 20 and 40 years. No costs or benefits beyond this are considered. Small variations in project life are irrelevant if a high rate of discount is used, because the value of a dollar 20 years from now would be practically zero.

There are a number of conflicting schools of thought regarding the appropriate discount rate for public projects; two will be noted. Low interest rates are often justified by using the rate of interest on ostensibly "risk free" long-term government securities. It is argued that this interest rate should be low because society, via government, is more concerned about the more distant future than are individuals or firms. Higher interest rates are justified by arguing that if the money was not used by government, it could be invested by private firms at the prevailing market interest rate. Thus, the "social opportunity cost" rate is taken as equal to the private rate. Wise analysts undertake computations with several different rates to see how the conclusions of the CBA may change. If this has not been done, the conclusion of a report can be made to appear very suspect by demonstrating that a small change in the interest rate changes present values dramatically and alters the ultimate conclusion.

Assume now that we have been able to work out the present value of costs and benefits for each of the alternatives: which is the best alternative? This simple question is not as easily answered as one might think. Clearly any alternative which has benefits greater than costs is socially desirable in net. Why not simply recommend the alternative which has the largest net benefit? That an alternative with smaller net benefit may be a superior project (more socially profitable) can be simply illustrated. In our case study, the costs and benefits of the proposed project may both be in the range of a hundred million dollars, so the difference between them - the net benefit - may be $5 million dollars. On the other hand, the costs and benefits of leaving the land as it is may both be rather small in comparison so the net benefit may be only $1 million dollars. However, the *rate of return* on investment (actual outlay) may be substantially higher in the second case - making it the more cost-effective alternative. The appropriate rule, in most cases, is to select that alternative which has the largest benefit-cost ratio. However, even this ostensibly objective rule can be compromised by analysts who have a vested interest in a particular conclusion. It is easy to demonstrate that the rank ordering of B-C ratios can be altered by appropriate redefinition of components. If the analyst likes the project, then treating a number of key costs as "disbenefits" (substraction from benefits) will usually succeed in markedly increasing the B-C ratio. Reports should be carefully scrutinized for evidence of such "fiddling".

Risk, sensitivity and equity

Among the difficult variables to deal with in any formal analysis are those which represent increased or reduced risks to society or individuals, and one should seek to uncover the strong value judgements which have been made. In our example, the proposed project may increase the risk of flooding in the ravine. In order to estimate the value of damages one must estimate the increased number and severity of floods. Past statistics, expert opinion and use of analogous situations elsewhere are typically used. However, in order to place a value on the risk, an assumption must be made about the population's degree of risk aversion. If people are highly risk averse, a strong case can be made for valuing the expected damages at more than the cost of repairing and replacing damaged property, etc.

The problem of uncertainty associated with forecasts of effects is much more pervasive than that of risk. Analysists can never be too confident about the predictions of future floods, future vandalism, future gas prices, future trip making

behaviour, etc. Such predictions should be based on common sense approaches. However, one should be very skeptical of predictions, not based on strong theory, for which no attempt has been made to indicate the degree of uncertainty or the range in possible future values. Sensitivity analysis is a name given to the process of systematic exploration of the sensitivity of conclusions to changed assumptions or values of predicted variables. Sensitivity analysis is particularly important when "guesstimates" must be made about the values of variables which are likely to be strongly affected by an alternative. The analysts owe it to the readers and decision-makers to indicate how the conclusions (the total costs and benefits) are altered if alternative plausible values are given to key variables.

Cost-benefit analysis is based on the assumption that the best alternative is the one which has the greatest social return on investment. It is fundamentally concerned with efficiency, i.e. the size of the pie which is to be divided among members of society. It is not particularly concerned with which particular individuals or groups in society win or lose. However, as was noted near the outset, it is impossible to reach any conclusion about what is good for society without using some (strong) value judgement about equity - that is, how the welfare of certain groups should be "traded-off". Almost all CBA's proceed on the (usually implicit) assumption that a dollar's worth of cost or benefit is worth one dollar, no matter who is affected. Individuals are thus weighted equally. (Some weights must be assessed in order to be able to add up the costs and the benefits.) It should be noted that equal weights are *not required* of the analysis; it is just the simplest and most common way of proceeding and tends to give the impression of being relatively "value-free". In fact, there is a built-in status quo bias in CBA which favours the existing distribution of real income and power in society. This "equal weight assumption" also has a tendency to favour urban development *versus* no-go alternatives. Although it is widely believed in our society (but cannot be proven) that the value placed on a dollar by the poor is more than that by the rich, most CBA's do not consider this belief. According to the conventional CBA calculus, a project which benefits the rich by $2 million dollars and costs the poor $1 million dollars may be the most cost-effective alternative. One way around this conclusion, which would be perverse to most people, would be to provide different weights for the rich and the poor. This has very rarely been done because the analyst would then be faced directly with the problem of providing the weights. It is so much easier simply to assume the weights are all equal.

The lack of concern for equity in formal CBA calculations is a principal reason why no one has ever recommended that CBA results be the only input into a public decision. With the criticism of the CBA in recent years, and the knowledge that principal winning and losing groups are usually not the same, it is now almost universally recommended that CBA documents have an obligation to point out exactly who (which individuals and socially relevant groups) pays - and how much - and who benefits and how much. The problems involved in pointing out the implications of alternatives for the (re)distribution of income are, in context, no larger than the other problems of estimation and evaluation which must be solved. It is rather easy to discredit, at least partially, a CBA which has not included such a discussion by arguing that the reason why it was omitted was that it would cast important doubts on the main conclusion of the CBA.

The discussion of CBA has, of necessity, been rather superficial and has sought to clarify some of the principles and problems involved. Although the theory underlying the method is the best that social science has to offer, there are many unresolved theoretical issues (e.g. the discount rate) and even more practical problems of obtaining data, forecasting the future, imputing monetary values, etc. The conclusion is that *any CBA* may be intelligently criticized on many grounds and that any criticism of a CBA may also be criticized. Any group which wishes to review a CBA should convene a committee of members who have studied economics, or else retain an economist.

SOCIAL IMPACT ASSESSMENT

The literature which calls itself social impact assessment goes back only less than a decade although, being essentially applied social science, its roots can be traced back much farther. Useful overviews of the relatively small literature are provided in the volume edited by Finsterbusch and Wolf (1977). Christensen (1976) provides a useful short discussion. The beliefs which seem common to this literature are remarkably few. There is a shared conception of the problem that SIA addresses; namely, to select the key social dimensions or social variables likely to be affected by a project, to predict how the project will change the baseline attributes, and to provide a social evaluation of these changes. It is thus the same problem addressed by EIA except over a range of variables considered to be social ones. There is also agreement that social impacts are likely to be very important ones, and there is little or no good theory upon which to draw for selection, prediction, or evaluation, and that all three phases will be exceedingly difficult. (Because of the dearth of theory, it is unlikely that this picture will improve significantly in the foreseeable future.) Nevertheless, there is also general agreement that a sincere attempt to deal with social impacts and to take them into account in decision-making is better than simply leaving them out on the grounds that nothing rigorous or general can be said. The dilemma is obvious.

Major viewpoints

The approaches to SIA advocated or used in the literature can be divided into two camps based on their views of how evaluation should be treated and than again into two camps based on their views of the desirability of "measurement".

The first view is that the assessment process is obliged to "evaluate" change. Proponents of this view argue that it is not really possible to remain objective in the sense of being value free and, usually, that this would not be desirable even if possible. This camp can usually be partitioned into those who would like to see evaluation reduced to a process of adding up changes, measured in commensurate units; and those who believe that, because adding up is so troublesome, it is sufficient to evaluate dimensions or variables separately. The former group would essentially like to see an attempt made to treat social variables as economic ones and to see cost-benefit analysis as the integrating framework. They argue that imputing prices and values, or some other common unit to such things as community spirit and an aesthetically pleasing environment makes overall evaluation much easier and is, in fact, no more problematic than creating *any meaningful index* which purports to evaluate. The latter group, while agreeing that measurement is generally desirable, would argue that if the assessment is able to provide indices of evaluation for each key variable separately, then political decision-makers should be left with the task of trading these off and effectively adding them up.

The second major view is that the evaluation process should be left to decision-makers because the assessor's task of predicting significant change is difficult enough without having to guess at the values and weights of society. It should be noted at once that this view is often at odds with the real terms of reference of EIA and SIA which requires "evaluation". Again, it is useful to divide this view into two camps. The first would argue that every attempt should be made to measure every variable at the highest possible level and to provide quantitative predictions. The second would argue that because there are a number of variables which cannot be measured, and because the process of measurement itself tends both to distort the true story and context of the problem and to give a false sense of security and accuracy, measurement is not desirable. This latter group then believe that the best picture that can be set before decision-makers is a narrative and qualitative one based largely on intuitive and unavoidably subjective reasoning. Little can be said in general about the way research should proceed with this latter view except that it should involve trained social observers who have become thoroughly familiar with the project and the society it is expected to affect.

The use of social indicators

Some researchers in all but the latter camp often have developed and used social indicators of various kinds in the process of conducting a SIA. The present authors believe that, although such indicators do have their disadvantages, they represent about the best device available for dealing with many social and related impacts. In our view, first clearly defining and then measuring as many social impacts as possible at a high level, even if it means selecting a few proxy or surrogate variables, is a distinct advantage. At least it is clear what precisely is being predicted and evaluated. We would not claim, however, that all social effects can be dealt with meaningfully in this way. In the remainder of this section we will discuss social indicators as useful indices.

Social indicators have a fairly large literature of their own and are usually considered to be part of the attempt in the last 15 years to construct quality of life indices. These latter have been proposed as replacements for GNP (gross national product) as a measure of social welfare or the human condition, and are argued to be a more broadly based single index. Such an index (or indices) could be used to compare countries or regions, or the same nation or region over time (for example, before and after a project or major policy change).

An idea of common types of social (and economic) indicators is provided in the second column of Table 9-1. This table is part of one given in Schaenman and Muller (1974), a report on a method of impact assessment for urban land development. Several other reports in the same series, by Muller (1975) and Christensen (1976) provide more detailed advice on how to handle specific types of social and economic indicators. The summary report of this series, Schaenman (1976) is an excellent overview. In addition, a rather complete list of social indicators is provided by Olsen and Merwin (1977). It is sufficient for present purposes to give a few examples of social indicators.

Health care

The impacts on the physical health of the community are often divided into two groups - those pertaining to the incidence of illness and death due to various diseases, and those pertaining to accessibility to health care. The former can normally be measured at a high level (as rates) whereas the latter usually cannot be. Two indicators of the latter are shown in Table 9-1 under C2. Physical access is often measured by the percentage of the population which is beyond a certain travel time or distance from the nearest hospital. (Note the same reasoning is used for schools, fire stations, and the like.) The reasoning is that social welfare is reduced as this percentage increases. The second indicator is the waiting time for hospital admittance for elective surgery. If the facilities are overburdened (congested), then elective surgery is the first to be deferred and the length of the queue grows. There is no pretence that these two indicators are the only two aspects of hospital access that people care about. Rather it is reasoned that these are particularly important, and likely to be *representative of a host of other measures which could be used.* Other obvious indices are average distance or travel time to nearest hospital, average waiting time for emergency treatment, and number of ambulances per capita.

Recreation

The impacts on recreational opportunities and their quality are often among the most important ones for urban projects requiring impact assessments or planning permission. The most common indicators used are those shown under C5 in Table 9-1. The first measures the overall level of satisfaction with public recreation opportunities. The second is a set of indices which attempt to measure the number of users or use occasions and the quality of the experience. For example, crowdedness is usually an important determinant of quality. Schools can be similarly treated, as can be seen under C6. The third, like the hospital care above, is the percentage of people who are within a certain travel time or distance from their closest facility.

Transportation

Most projects affect local transportation directly or indirectly. Included in transportation would be private vehicular transportation, public transportation, pedestrians, cyclists, etc. A number of useful indicators are listed under C7 in Table 9-1. The best single index is the average travel time or cost in going between selected common origins and destinations. For example, a new bridge would tend to decrease this index, whereas a new apartment - generating additional traffic - will tend to increase this index. In addition, access to public transportation (e.g. bus stops) and accident rates are usually considered to be very important.

Some others

Several indicators for crowdedness, sociability and friendliness are listed in Table 9-1 under D4 and D5. It is clear that these attributes of a neighbourhood or comminity are even harder to measure at a high level than those noted above. Two of the three indices use a very common way of dealing with perceptions of the neighbourhood. The goal is to assess the change in the percentage of the community which perceives the neighbourhood as "too crowded" or "very friendly". This can be determined through a survey. Note that a high level of measurement has been achieved. It is also very important to note that what is important here is not a measure of crowdedness or friendliness, but rather a measure of the *perceptions* of the changes which will take place in these.

Aesthetics

The indicators listed in Table 9-1 under E1 abd E2 for aesthetics and cultural values also rely on this approach. However, this may be one attribute which it may be impossible to measure at a high level even in proxy form. A major problem with attractiveness and view opportunities is to determine what exactly is being evaluated. The context of interaction between man and milieu depends on many highly variable factors, such as the viewer's purpose, familiarity, mood and circumstance; the weather, light, time of day and season; whether the views are taken from on foot or in a vehicle, and whether they are deliberately chosen or accidentally come upon. Even if these unknowns are resolved by the analyst, he or she must then resolve another fundamental problem - how should landscape be evaluated? The need to address this question arises from the presence of variability whenever human values are involved. Replicating the average value and using this for evaluation and decision-making in this instance will systematically reduce the variety of landscapes present in the environment. It is obvious that such an approach serves few people (including the "popular" majority) particularly well, and that what are needed are evaluations (and decisions) which are sensitive to the variety of interests and values present in society.

Values, social evaluation and decision-making

Many social impact assessments very cleverly try to avoid the issue of evaluation by attempting to present a dispassionate view of change. Most, in fact, end up evaluating change without ever facing up to the problem of whose values are being used (or should be used) and why. Very profound criticism can be levelled at such assessments - first by pointing out that the value basis is not stated and second by suggesting or demonstrating that, in some sense, the wrong values were used.

The answer to the question of whose values should be used is, in our view, rather subtle and two-pronged. First, assessors should evaluate the predicted change in the variables (good, bad, how much so) from the point of view of the society directly affected - usually the community or neighbourhood. Secondly, an attempt should be made to *evaluate the evaluations* of those in the neighbourhood *from the point of view of a broader society* - say the metropolitan area, the province, or even the country. The differences can be illustrated with respect to our exemplary project. It is very likely that the evaluation of the social effects of the low income apartment project by the directly affected local community will be

negative and perhaps quite strongly so. Nevertheless, it still may be that, in net, the project is socially desirable because of the positive social and other effects to a broader society which, for example, may place greater value on housing the poor than the social disruptions the poor may stimulate in this small middle class area. Dealing with this second level, broader societal evaluation is precisely the same problem as deciding on weights to place on individuals (or groups) in cost-benefit analysis, except that it is even more difficult because the things which require weighting are often poorly defined and not even measured. Perhaps the best thing which can be said about the evaluation process is that a good job should be done on the question of how the affected community evaluates the change and decision-makers should be left with the task of placing these in broader perspective.

The community's evaluation of change may be estimated in a number of ways. The same reasoning applies here as was used in the discussion of prediction earlier. First, experts can be asked to predict people's evaluation of change. The case can be made, however, that whereas experts have special training which allows them to predict effect, they have no special attributes allowing them to deal with social evaluation in its deep sense. This may not be true of certain social psychological effects. One of the most expedient ways of dealing with evaluation is to ask community leaders. It could be argued that, in principle, community leaders are particularly well situated to be able to provide representative evaluations on behalf of the community. The task would then boil down to presenting a balanced picture of the different evaluations likely to be provided by different interest group leaders. For example, the president of the local "neighbourhood preservation association" and the president of the local business organization (largely shop-keepers) will likely have different views of the case project noted above. One way of dealing with divergent evaluations is to report the numbers of persons likely to share positive and negative evaluations - preferably by strength of preference.

Public participation and sample surveys

One of the most common methods for dealing with evaluation is the direct involvement of the public. This may be done by open meetings, through some form of written questionnaire, telephone survey, personal interview, or some combination of these. A great deal has been written about suitable public participation processes because it now seems to be generally believed that the public should be directly involved in one form or another. Very little will be said about the various issues involved here.

While meetings may be appropriate for finding out the issues of most interest to community groups early in the study, they are not well suited for accurately determining either the range in preferences or evaluations, or their relative strength. Surveys of representative citizens are much better suited to the evaluation task. Ideally, the sample should be taken in such a way that every view is represented and undue weight is not given to any particular group. The best sampling strategy under these conditions is a stratified sample. This is a sample in which key groups, likely to hold different views, are identified and a particular quota of individuals or households in each group is then surveyed. The basis for selection within each stratum or group should have a strong element of randomness in order to avoid bias. While aspatial sampling designs are often suitable, the best approach in most situations would be to select spatially defined regions as the strata. Because the impact of most projects is expected to vary with distance from the project, the best spatial strata in most cases are, in fact, roughly concentric zones centred on the project site. As a good rule of thumb, which incidentally makes subsequent generalization easier, it is best if the number of persons/households sampled within each stratum (zone) is roughly proportional to the number of people in the stratum. For an excellent discussion of geographic sampling methods, the interested reader is referred to Dixon and Leach (1977a).

Questionnaire and/or interview design is a very important factor underpinning the accuracy of the results. In addition, qualifications must be commonly placed on results because people do not always say what they believe and because people in such cases are inclined to overstate their preferences or values to affect the conclusion.

An examination of many questionnaires used in impact assessments will reveal that many questions have been asked in the wrong way or in the wrong order and some are phrased in such a way as to suggest that there is a right answer. (e.g. "Most citizens believe that the project is aesthetically pleasing, do you agree?") Because social impact assessments often rely heavily on the results of surveys, a critic's time is very well rewarded by careful scrutiny of the questions asked, their order, the instructions given, and so on. Dixon and Leach (1977b) provide an excellent introduction to questionnaires and interviews.

If the purpose of the questionnaire is to obtain both predictions and evaluations this should be made clear in the questionnaire. Questions relating to predictions should be asked before those relating to evaluation; often side by side in a table format is the best. If the purpose is to obtain evaluations alone, it is important that some idea of the *predicted effects* be provided first. For example, people should be told that "experts" (police officials/sociologists) expect that the rate of vandalism will increase by 20% to five incidents per week on average, before citizens are asked to evaluate the effects. In fact, this is not done in many cases so that it is difficult to know what the responses mean. There are a number of ways of obtaining evaluations in questionnaires and interviews. Asking people to describe their evaluation in their own words is not very helpful as there is then the problem of summarizing the results. The simplest, and perhaps the best way, is to provide a set of rank ordered boxes, as below, and ask people to check one.

very bad	bad	no strong feelings	good	very good
☐	☐	☐	☐	☐

Five and seven point scales seem to be the best. Alternatively, people could be asked to place a mark anywhere on a line representing a continuum between, say zero to ten. In the former case, results can be summarized by reporting the frequencies of different responses. In the latter case, the actual mean or median position on the line can be reported, but it should not be treated as a high level measurement in any subsequent analysis.

Whether or not an attempt should be made to provide a synthesis of the results of any exercise designed to elicit evaluations or weights depends on what is required. Most researchers would prefer not to attempt to add up the evaluations of different effects. When such an adding up process has been undertaken, it can always be criticized in some way.

9.5 CONCLUSIONS

The socio-economic subsystem of the environment is one which is affected by all kinds of projects. It is clear that socio-economic processes are among the most complex and least understood of all those to be considered prior to the allocation of resources by society. There is simply very little good theory. Exacerbating this fundamental dificiency is that the socio-economic subsystem will certainly be the one with the largest proportion of relevant variables which are not measurable at a high level. Indeed, for many of the relevant variables, such as aesthetics, it is not meaningful to "measure" them at all.

Nevertheless, planners and impact assessors are obliged to consider the direct and indirect impacts of proposal developments on society and the economy since the welfare of people in society is the raison d'être for all forms of planning. We have sought in this chapter to describe what theory and high level measures are available for this task. We have also stressed that any planning document or impact assessment must deal with establishing a baseline body of data, predicting how the important baseline variables will be changed for each alternative, and finally evaluating the significance of these changes from the point of view of social welfare. For the socio-economic dimension of the assessment problem, it is particularly critical to distinguish between the prediction and evaluation steps. Many analyses appear to side-step the fundamental problem of *social evaluation*; we have strongly argued that this is simply not possible.

Consequently, the task of socio-economic assessment is really almost an impossible one; there is no such thing as a perfect set of social values and, therefore, no possibility that perfect or "correct" assessments can be carried out. It follows, therefore, that much more attention must be given to providing decision-makers with high quality (measured) data bases and prediction. Even in the case of assessments that are well done, the critic's job is probably the easiest of all.

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CHAPTER 10

WRITING UP A FIELD STUDY

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10.1 INTRODUCTION

An investigation made about an urban natural area will normally be communicated to others in the form of a written report. Even if an oral presentation is required, it is good practice to organize your data into a written report, with appropriate tables, graphs and figures. These tables and figures can also be made into slides or transparencies for projection and the written material can be used for reference when you prepare to speak.

The foundations of a good report are laid at the planning stage of the investigation. The objectives of the report will normally be identical to those of the study or investigation itself. This means that a poorly or inadequately designed study cannot result in a very good report. Quite simple procedures such as the preparation of standard data collection forms will guard against errors and omissions which are discovered, but which cannot be remedied at the report writing stage. However, even a well planned study which generates potentially good data is still not guaranteed success if the report is poorly written, or the data presented in a confusing manner. One serious consequence of an incompetently written report can be a negative impact on your audience or your opposition and a loss of credibility for your group.

For the most part, the information set out in this chapter applies to a technical report. While the basic format of working objectives, with methods, results and discussion of the results can be applied to any well-organized report, the details and examples here are for rather technical subjects including biological, ecological, physical and possibly chemical data. Since this is a book on natural areas most of the examples have been chosen appropriately.

Even if your report itself is entirely non-technical, you may often have certain scientific information available which would add weight to your case. This can be supplied as appendices, and the advice in this chapter on organization of data tables may be of value.

There are certain rules and conventions which cover the vocabulary, units of measurement and their abbreviations for given disciplines. Even if your report is not judged to be highly technical, it should attempt to conform in these respects. The most obvious value of this is to facilitate communication and comparisons between your work and the work of others, amateur or professional. A simple example is the use of latin names for living organisms; this is a universal convention and avoids the ambiguity which may result from the use of common names (common names can of course be included as well; they are often more attractive than the latin!). Another obvious example is the use of metric units of measurement, and a third is the convention for labelling the axes of a graph, with the independent variable (time, sample number, distance along a transect, etc.) on the horizontal or x-axis.

The form of the report normally follows the traditional "method, results, conclusion" progression, with the following headings "*Introduction, Aims and Objectives, Materials and Methods, Results, Discussion of Results, Conclusions, References*". Further, an *Appendix* or *Appendices* of additional information may be supplied, and some reports begin with an *Abstract* or *Summary*. This chapter will outline some basic rules, some common pitfalls and some examples for each of the sections.

10.2 THE INTRODUCTION OF THE REPORT

As the name implies, this should serve to introduce the subject of the report. It will normally contain some historical or background information, and references to other observations, hypotheses or unanswered questions which stimulated the current study. It should be concise, which does not automatically mean it will be brief. If it has to be more than one or two pages, however, it is advisable to use sub-headings which will provide focussing points for the ideas in the introduction.

A writer is sometimes faced with a dilemma concerning the presentation of studies related to the current project. Should they be included in the introduction, or in the discussion? While there are no absolute rules, it is advisable to limit the introduction to two major topics: the background information and the development of this only as far as a definition of purpose for the present study, which will then lead logically into the second section, and leaves the dialectic for the final discussion.

10.3 AIMS AND OBJECTIVES

For the present purpose, the aims represent the over-all goals of the study, and the objectives the more specific and appropriate ways in which the aims are to be achieved. For example,

> "The aim of the study is to make a comparison between the soils in two ravines.
>
> The objectives are:
>
> 1. To construct transect profiles across the two valleys.
>
> 2. To make site descriptions for each point on the transects.
>
> 3. To log for each profile the colour, texture, structure, organic matter and pH.
>
> 4. To present the values obtained in 3 in graphical form for the two ravines and determine points of similarity and contrast."

The objectives, however simple, should be stated at the outset, and should not be buried in the results and conclusions. A statement of objectives helps you, the writer, to organize your materials. As well, the objectives can often be restated as a useful framework for the discussion of results.

10.4 THE MATERIALS AND METHODS SECTION

Preliminary planning and research should have established which methods are appropriate for your study. On occasions, it is necessary to modify a technique or combine two or more methods. How much of this is necessary to describe in writing? A very practical and testable guideline is to include sufficient information so that another worker could repeat the procedure which you used. Therefore, this does not require tedious word-for-word repetition of a method which has already been described elsewhere. Such a "standard method" need only be referred to by name, and the source of the original method cited properly.

If you have modified an existing method, or devised a new method, then it is essential to describe it clearly, bearing in mind the guidelines mentioned above. Diagrams, plans or photographs of apparatus and workers in operation can often provide information in a more useful and practical form than a long description. The financial limitations underwhich most studies of natural systems by amateurs are carried out means that sophisticated equipment is rarely available, and indeed it is rarely necessary. With ingenuity and imagination, you can produce simple and effective tools from inexpensive starting materials. For example, nylon stockings and metal preservation jar tops can be used to make plankton nets or insect nets;

kitchen sieves can be used to capture small invertebrates; juice cans can be modified to compare the moisture-holding capacity of soils; many simple instruments for making meteorological measurements can be made by the home handyman. For more ideas and examples, the reader is referred to Hopkins (1973) and Andrews (1972) and the magazine "Weather".

The materials should be described according to the same guidelines as the methods. Try to avoid reference to a chemical substance or other materials by a trade name alone; provide enough information for a worker in a different region to obtain a substitute if a given brand is not available.

For specific chemical compounds acquired from supply houses, the report should state clearly the grade and quantity required. If one tries to order some hydrochloric acid from a chemical company, there are a least six listings in the catalogue and a great variety of sizes and packagings. For certain common substances; e.g. sugar, the commercial product is quite as free from impurities and is cheaper than the chemical compound obtained from a laboratory supplier; 453 g (1 lb) of $C_{12}H_{22}O_{11}$ costs $6.00, 1 kg (2 lb) of table sugar from the grocery store costs about 75¢. Any inclusion of tips and hints of this nature can make your report of more practical value and also give it individuality and added interest.

10.5 THE RESULTS SECTION

MEASUREMENT

Measurement is defined as the comparison of an object to a standard. The measurement is expressed as a *magnitude* with an accompanying *unit*,
e.g. 12.5 m (metres); 2.1 g (grams).

For a table of units, including multiple and submultiple units, the reader is referred to Appendix 1. Some useful conversions are supplied in Appendix 2.

Accuracy and significance

Two relevant questions concerning measurements are:

Firstly, how acurately should the measurement be taken? The solution is often dependent upon the problem; for example, a farmer fencing a field of 200 ha need not be concerned about boundaries within one metre, but a surveyor of a 50-storey building will wish to establish boundaries within a fraction of a centimetre.

In short, in your studies be guided by your objectives. Soil profiles can be delimited to within centimetres; the additional time required to measure to millimetres (which could not be done accurately anyway) would not be justified. In contrast, the indentification of two similar species of insects may require you to measure an appendage length to within 0.1 mm in order to distinguish between the two species.

Second, how many digits should be provided in a measurement? Conventionally, the number of digits which are reasonably reliable and are retained are called *significant figures*. For example, on a ruler which is graduated to 0.1 cm, one would express the measurements to the first decimal place. The second decimal place, although estimable by eye, is not really reliable.

If one were taking an average of a series of measurements from the ruler, the calculation might result in number with five decimal places. However, because we know that only the first decimal place is reliable, we should round off the average to the correct number of significant figures, e.g. to calculate the *average* of the following: 2.5, 3.1, 2.8, 1.9, 3.2, 2.0 cm (measured with the ruler graduated to 0.1 cm); the average is 2.583333 recurring ... and should be rounded to 2.6 cm.

Error

It must be recognized that no measurement is absolutely correct, but contains uncertainty or *error*. Error may be *systematic* or *random*. *Random error* is due to limitation in reading the measurement - for example, if we weigh the same object many times on a balance we will not always get exactly the same value. The worker cannot eliminate or avoid random error, but it can be minimized by *repeating* measurements and *averaging* the results.

If the value changes in a manner which appears to show a *trend* or *bias*, we may have a *systematic error*, which is likely due to a limitation in the measuring device. A rather sad story illustrates this:

> A limnologist was recording the depth of a pond at various locations, using a rope to fathom the depth. After working all day, he discovered his rope had uniformly shrunk 2 m.

Such a systematic error often cannot be corrected. Therefore, beware of the shrinking rope, or its analogue on land!

The meaning of the mean

The mean, or average, or arithmetic mean is probably the value most frequently used to condense or summarize data. The mean or average can, however, be misleading. In the example shown below, ten trees were measured in two stands of paper birch (*Betula papyrifera*). The report stated that both stands had trees of average height ($\bar{x}$) 2.4 m. However, the original measurements were as follows:

Stand 1	Stand 2
2.4	2.6
3.1	2.5
1.2	2.3
1.8	2.4
2.1	2.4
1.9	2.2
2.5	2.5
1.5	2.6
4.5	2.3
3.0	2.2

i.e. tree height in Stand 2 was quite uniform, while in Stand 1 it was extremely variable. The simplest way to give an indication of such a difference is to include the *range* of values, as follows:

Stand 1 $\bar{x}$ = 2.4 (1.2 - 4.5)

Stand 2 $\bar{x}$ = 2.4 (2.2 - 2.6)

A simple statistic which can be readily calculated is the *standard deviation*. Many hand calculators have the capacity to calculate this for a set of values from which the mean is taken. Either the range or the standard deviation should always be supplied with a mean value. As well, the number of observations ("n") should be given. In addition, if space and cost permit, columns of original ("raw") data can be supplied in an appendix to your report. In this way, nothing is hidden; for the reader who wishes to make further calculations or do statistical tests, the data are available.

Implicit in this discussion is the assumption that data will not be suppressed or omitted unless there are defencible reasons for doing so, in which instance they should be stated. Natural phenomena rarely fall into sharp categories. "Identical" items are never completely identical, and a degree of variability is to be expected. This is why biologists must always take several (replicate) samples for a given area, and ideally determine the degree of variability. If you encounter a great

deal of variability for a particular parameter in samples *within* one area, and wish to compare with another site, it will be necessary to use some simple statistical tests of significance which are outside the scope of this handbook. For further information see Clarke (1969) and Heath (1970).

The presentation of figures and diagrams

As mentioned earlier, figures and diagrams can be valuable for conveying information, and can save words. Two rules which should be observed are:

(a) Every figure or diagram should have a number, and a title or legend, and should be self-explanatory.

(b) Every figure or diagram should be referred to, by number, in the text. If this is not done, the illustration, however instructive, may be missed, or not seen in context.

If you consider the frustration you experience when a newspaper photograph has no caption, and does not appear to be related to the columns around it, then you can understand the more serious consequences of omitting to do either a or b.

Figure 10-1 illustrates the essential components of a graph or diagram. In the instance of diagrams which are not graphs, a reference size, or scale or magnification should be shown.

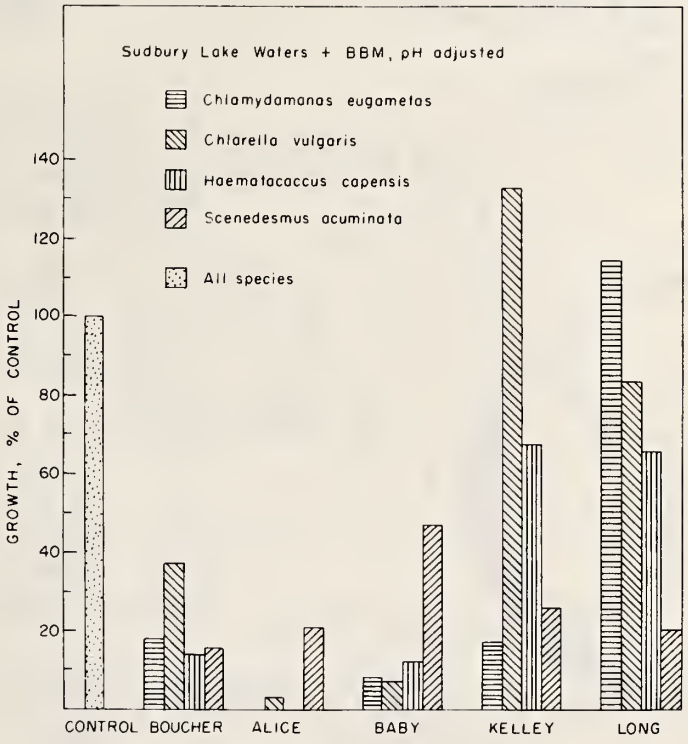


Fig. 10-1. Bioassays of growth of four algae in lake water from Sudbury with the pH adjusted to 6.8 and supplementary nutrients

Tabulation of data

Two methods are used to organize data - the tabulation of information and pictorial presentation.

At every stage of an investigation, time spent putting data into a table will save time in later stages. Figure 10-2 shows how data from a bird census might be received from a team of helpers.

Grenadier Pond	Mallard	Black	Pintail	Wood
	427	232	45	17

Mallard 73

Humber R. 12 Wood 19 Pintail 32 Black 73 Mallard

Black, 36
Pin, 21
Woody, 2.
Mall, 127
} Don River.

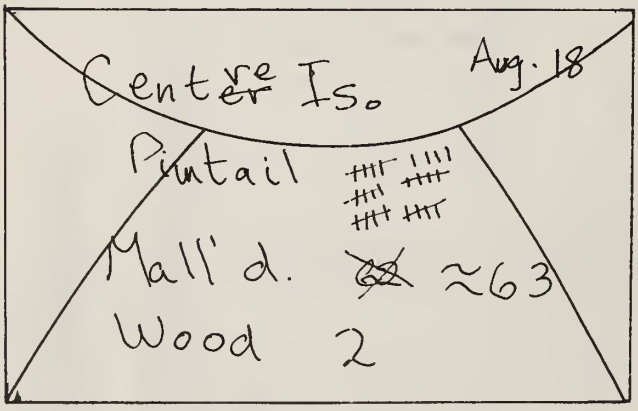


Fig. 10-2. A bird census data on 4 duck species from 4 areas. (Each site was observed by an independent "birder")

If a simple census sheet had been prepared in advance, the data could have been entered by the individual workers and the same format used for summary or compilation. Table 10-1 shows the solution.

The entire subject of field recording deserves attention. As well as standard data collection forms, suggested here, field diary procedures have been developed by most large groups.

Table 10-1.

Date / Location	Duck Species				Total	Average
	Mallard	Black	Pintail	Wood		
Grenadier Pond						
Humber River						
Don River						
Centre Island						
Total						
Average						

The next example (Fig. 10-3) is a further illustration of how not to record data!

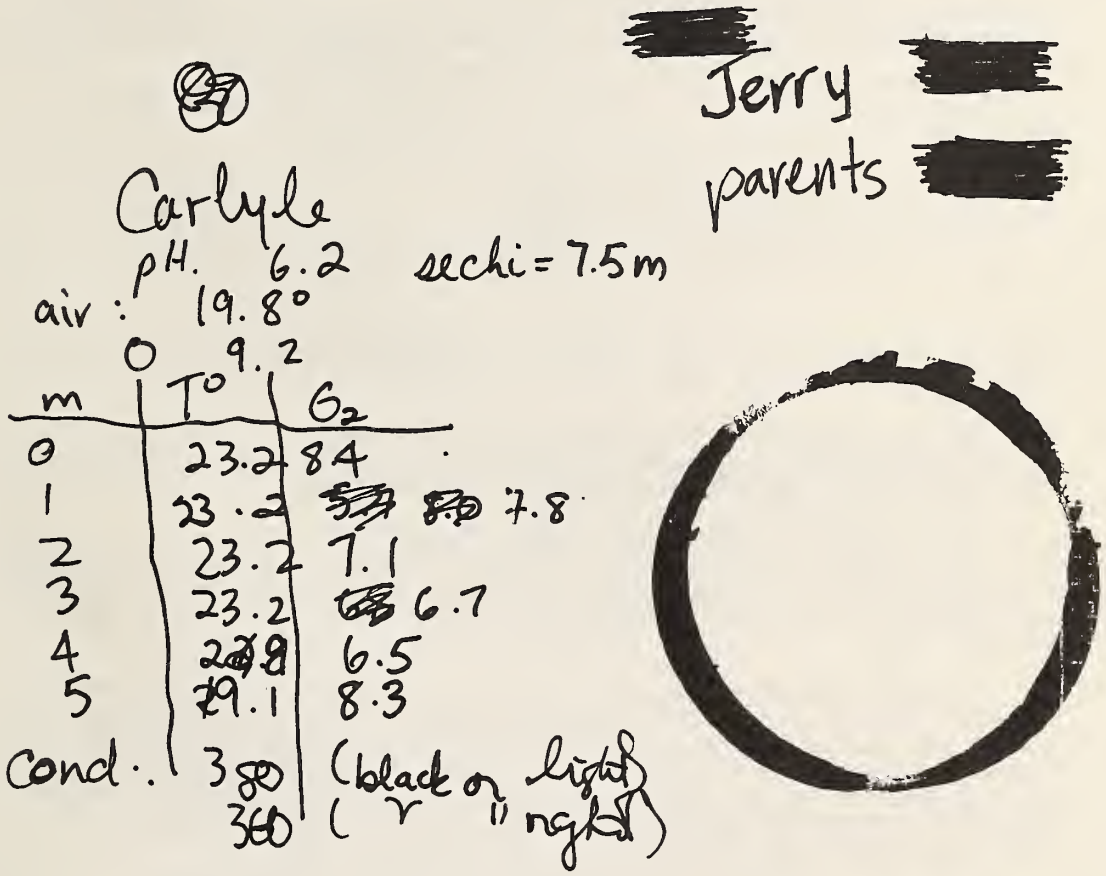


Fig. 10-3. An original sheet of raw data for chemical analysis of lake waters, collected and analysed in the field.

While these examples are somewhat extreme, they are not unique, or even exceptional. With the availability of waterproof notebooks and pens, and the preparation of suitable blank forms, most field recording need only go through a single step of transfer before it is ready for use in a report, or for further analysis and consolidation.

Tables in the report should be set up according to a few simple rules: the different groups (areas, species, experimental treatment, etc.) should be set up in columns or rows, separated by spaces or lines. Columns should have clear headings, including where appropriate the units of measurement, in order to avoid repetition. The table should bear a title which renders it self-explanatory. It should be simple, comprehensible and visually satisfying, and should not attempt to convey too much information. Properly tabulated information allows the data to be easily analysed, e.g. in an observation of the effects of fertilizer on five plant species, the following data were produced.

With #1, 25.3. Without #1, 21.0 With #3, 20.00. Minus #3, 22.0.

#4 with 26.3. #4 without 23.0 etc. etc.

This should have been tabulated as in Table 10-2.

Table 10-2. Effect of fertilizer on the growth of five different plant species

Plant Species	Average plant height in cm	
	with fertilizer	without fertilizer
1	25.3	21.0
2	26.3	21.8
3	20.0	22.0
4	26.3	23.0
5	27.5	19.3

Then, if the "fertilizer effect" (which is plant height with fertilizer minus plant height without fertilizer) were required it could easily be calculated.

So far we have been considering tables which would be used either in the body of the report (normally the summary table) or as an appendix (normally the record of original data). The two serve rather different purposes.

The summary statement table is most often in the form of totals or averages for a large amount of information, or a selection from a data set which represents a typical situation. In making a summary table, the writer has to use his or her own judgement as to how far to condense or select, and in this sense is making an interpretation.

A raw data table on the other hand (such as a census record) is a permanent record of collected information and should normally be put in as an appendix. If massive raw data tables are included in the body of the report, they merely "pad" the report, and give the impression that the writer does not perhaps understand or care to interpret the information. Ultimately, it is you, the writer, who must make judgements on the form and position of the tables in a report. Always consider their effectiveness from the reader's point of view.

Mapping and survey data collection

Planning and standardization of data collection is crucially important in the area of natural feature mapping. Points which need to be clarified at the outset of mapping exercises are standardization of symbols, units of measurement, and the scale at which mapping is carried out. It should be possible for the reader of the report to locate precisely the natural features mapped or described, and ideally to

be able to make comparisons with other data. For this reason, conventional signs and methods are preferable to novel ones. As a general rule, do not introduce a new system unless you can justify its use over conventional ones.

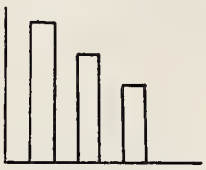
Bar graphs and pie diagrams

Information can be illustrated by simple diagrams such as those shown in Fig. 10-4. Practical use of such diagrams is shown in Fig. 10-5, 10-6 and 10-7. Each diagram should have a title, axes labels and a key to any symbols used.

A. Pie Diagrams

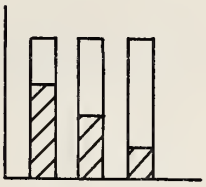
The segments within the circle are shaped like pieces of a pie

B. Bar Chart



The different sized subdivisions are shaped like a series of bars

C. Proportional Bar Chart



Identical sized bars are internally subdivided or proportioned within each bar

D. Pictogram

In this illustration information is represented with a picture which in some way is related to the data

Fig. 10-4. Methods of illustration for qualitative information

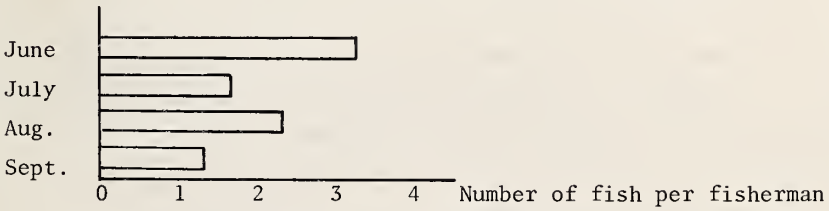


Fig. 10-5. Average number of fish per fisherman in the Credit River for summer months of 1976 of a 100 randomly sampled fishermen

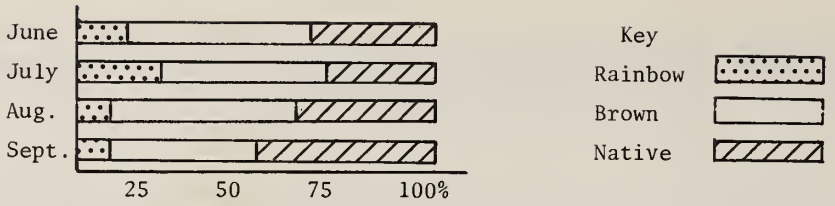


Fig. 10-6. Percentage of composition of caught fish species in fishermen's creel for the summer of 1976 of a 100 randomly sampled fishermen

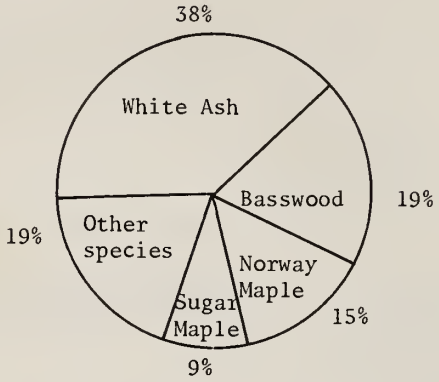


Fig. 10-7. Tree species of Rosedale Valley, Site #1 (north facing slope) 153 trees

The pictogram uses the actual shape of the object examined to represent the composition. For example, the types of buildings are represented in Fig. 10-8.

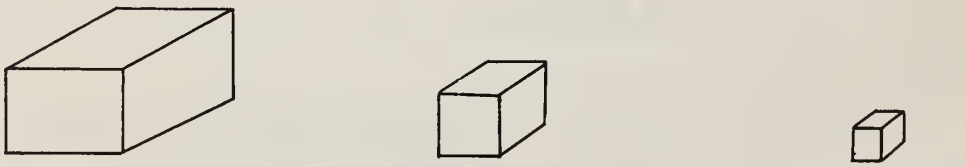


Fig. 10-8. Relative amount of buildings in an urban area

Unfortunately this method of presentation, although easy to grasp, can be misinterpreted. It is implicit that the values for Fig. 10-8 were based on the objects' volume. If numbers are converted to pictorial representation, care must be taken to ensure that, for example, linear measurements are not used for pictures portraying volume.

Continuous data - histograms and line graphs

In general, continuous data are more difficult to represent than discrete data. For example, it is simpler to diagram the difference in numbers between counted groups of trees than to illustrate the difference in height in the groups.

A useful device is to condense continuous data into *classes*, and then to draw bars corresponding to the frequency within each class. Using the example of tree heights, the stages for construction of a histogram are shown.

Values for tree diameter (in cm) of sugar maples from Parkdrive Ravine are:

35, 6, 27, 19, 16, 14,

2, 15, 12, 21, 18, 23

Based on the classes of 5 cm intervals, the following table of groups is set up (Table 10-3). In this instance, the table could *not* be used to collect the raw data, since all the values need to be known before the classes are set up.

Table 10-3. Tree diameters for sugar maple in Parkdrive Ravine, arranged in classes

Group number	Class limits in cm diameter		Frequency
	lower	upper	
1	0	5	1
2	6	10	1
3	11	15	3
4	16	20	3
5	21	25	2
6	26	30	1
7	31	35	1

Actually the class limits should run in a continuum but since no fractions of a centimetre were measured, no values fall outside the classes.

The axes for the histogram have frequency on the y-axis and the variable on the x-axis. The resulting graph is shown in Fig. 10-9.

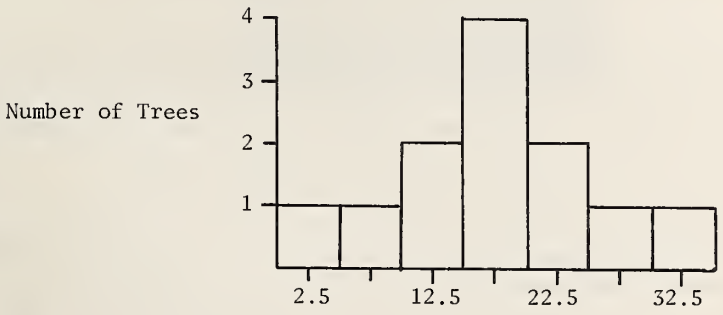


Fig. 10-9. Frequency of diameter of distribution on 12 Maple trees from Parkdrive ravine, Toronto

In most instances, particularly when many values are involved, the immediate impact of the graph is more effective in conveying information than a table of values. However, some details of information may have to be sacrificed and once again, the author of the report makes the judgement on method of presentation.

Line graphs can also be used to illustrate quantitative data, and a simple example is shown in Chapter 7.

The construction and presentation of line graphs follows the basic rules already presented. Once the axes are suitably scaled and labelled, the data points are plotted and lines drawn to join them up. In its simplest form, a "broken-line" is produced as shown in Fig. 10-10.

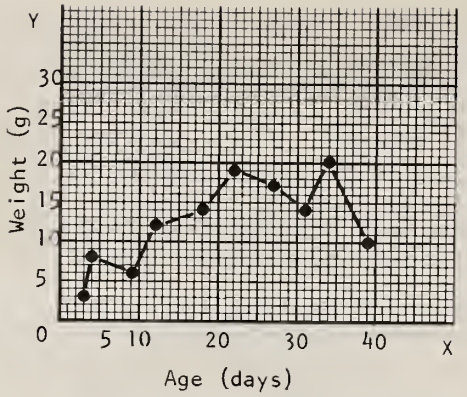


Fig. 10-10. Broken line for weight of fungus in a growth medium

Often the points fall on a smooth curve, or look as if they should fit on a line. Where irregularities are due to small variations, a "best fit" line can be drawn, a procedure sometime called "smoothing" (Fig. 10-11). However it should be noted that if one ateempts to "fit" a smooth curve or a straight line to a set of points, one is essentially making a mathematical statement that the data fit an equation for that curve. Therefore, caution should be exercised and if serious doubts exist, it is safer to use a broken line, which implies no mathematical relationship.

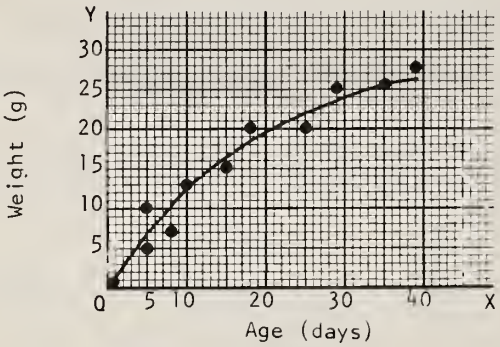


Fig. 10-11. Smoothed curve for weight of fungus in a growth medium

Finally, a word on extrapolation and interpolation. Figure 10-12 illustrates how a curve can be extended beyond existing data points, and thus predict a situation in the future. This is called *extrapolation* and once again should be used with caution since it can give rise to serious misinterpretation. However, in some situations there is no more reliable estimate of future trends than an extension of existing ones, and the device if based on sound data and used responsibly is acceptable. If you have serious doubts or if the extrapolation is going to be used in a confrontation, you would be wise to consult an expert! You should also note the section on how to mislead with graphs below.

Writing the results - how much prose?

Presentation of results will vary according to the type of investigation, but organization and the orderly procession of information is most important. A report which is entirely descriptive or consists of qualitative data can become very tedious in the results section. Even if no numbers are generated, it is still possible to tabulate and summarize observations in tabular or graphical form. Since it is not necessary to repeat in prose everything that appears in tables and figures, tabulation of results economizes on words, and can make the text more "digestible". Remember, however, that every figure or table must have a reference in the text.

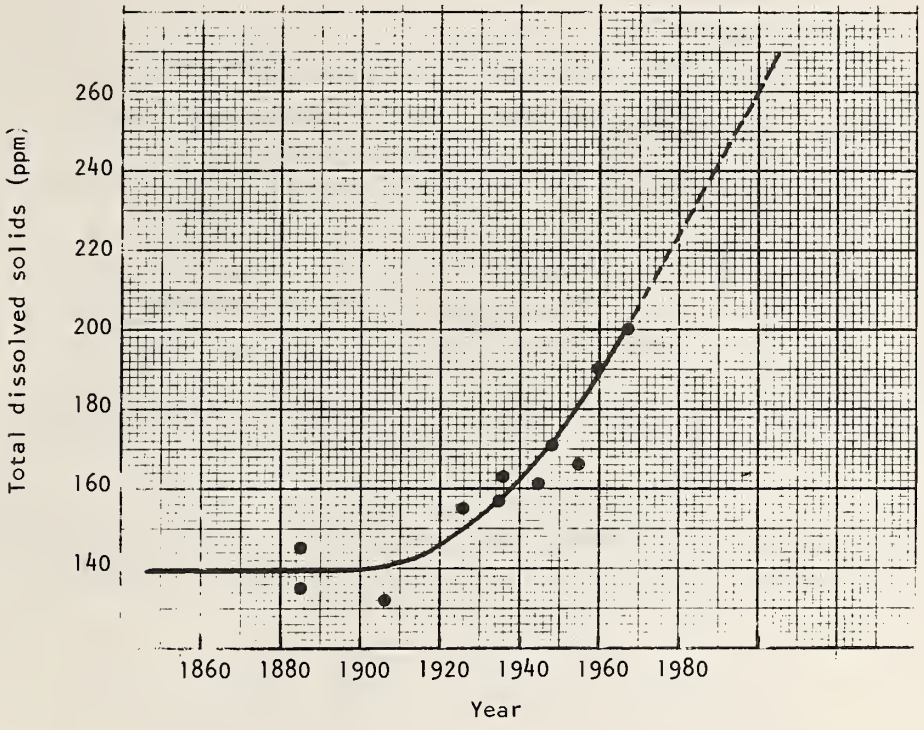


Fig. 10-12. Changes in chemical characteristics in Lake Ontario (adapted from Meadows *et al.* 1972)

Normally, the results should stand clearly apart from their discussion and interpretation although as already mentioned, a degree of interpretation is involved in composing summary tables and figures. There must be absolutely no confusion for the reader concerning which material in the report is the original work of the writer and his group.

In summary, the results section should be clear and readable, with imaginative use of devices for summarizing and integrating data, and should normally include only original work.

How not to mislead with graphs

The devices of selection, condensation or summarization of data are all open to abuse. Deliberately or inadvertantly, the writer of a report can mislead his reader. While his objective may be basically honest, his conviction may be so compelling that he will reject or suppress data which do not support his hypothesis or belief. For example, in the graph shown in Fig. 10-13, the numbers of species of herbs is plotted against distance from roads at a number of different sites. There is no apparent relationship between the two parameters. However, if one section of the data is plotted on an expanded scale and a best fit line is drawn, a completely different impression is given in Fig. 10-14.

In Huff's book "How to lie with statistics" (1954), more varied and sophisticated examples are give. The main message here is to be completely honest. If raw data are presented in an appendix, and justification made in the text for any selections or omissions, you cannot be faulted or accused of trying to mislead.

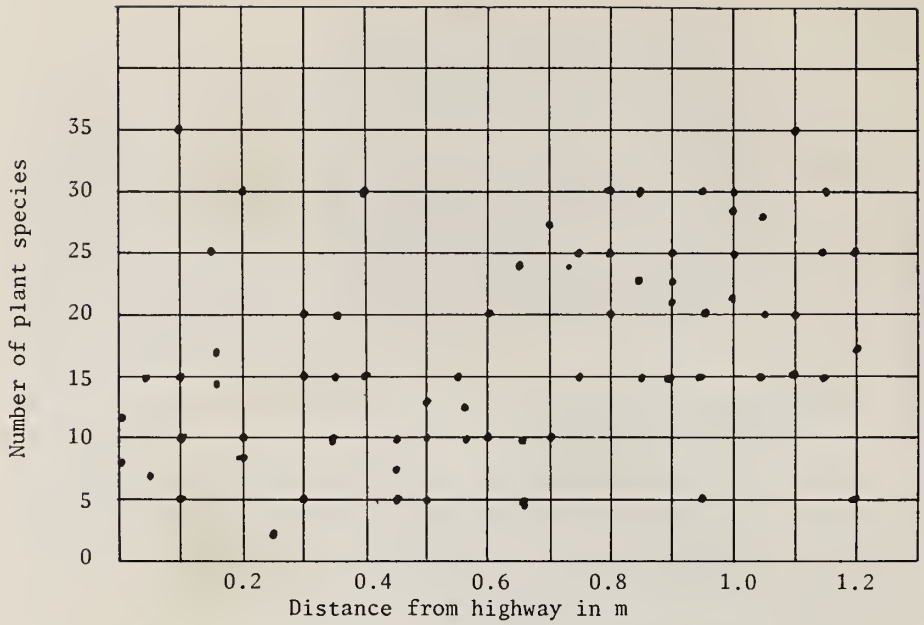


Fig. 10-13. Numbers of plant species recorded in sites beside highways

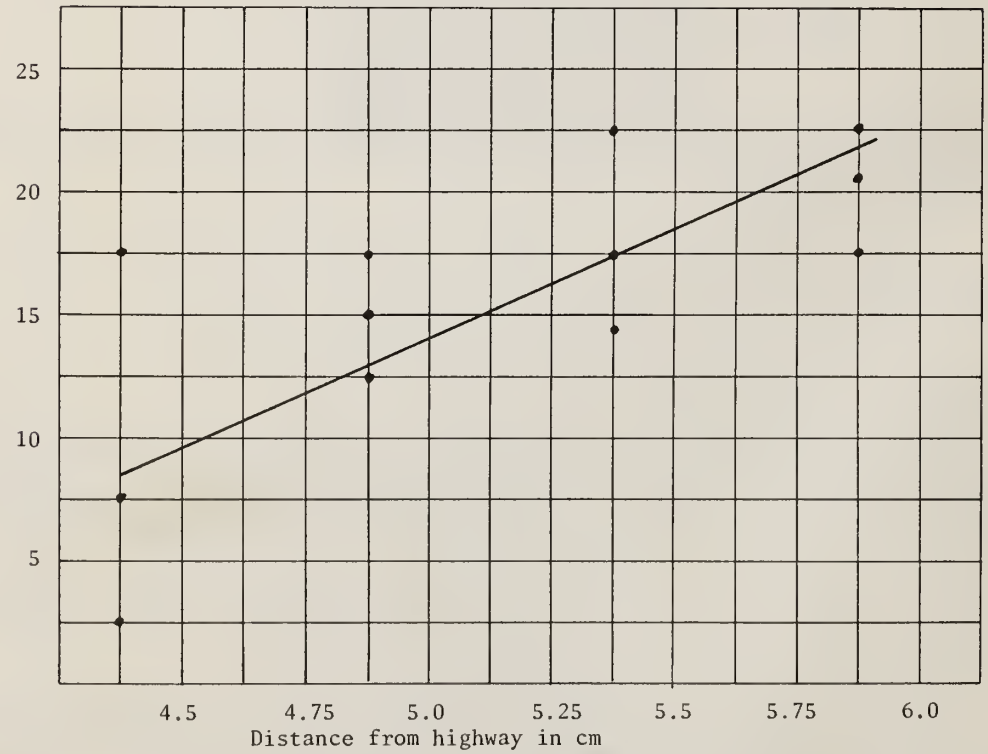


Fig. 10-14. Numbers of plant species recorded in sites beside highways

10.6 THE DISCUSSION

The discussion is your opportunity to comment on and interpret your own results, to discuss them in terms of other work done, to be speculative, and to make recommendations. The discussion can be very brief, or quite extensive, but it is good practice to make reference to the stated aims and objectives, and to conclude the discussion by closing the circle which began in the introduction. When you cite other work, remember that your reader may wish to obtain the original reference material, or contact the person whose name is given. Bearing this in mind, provide as much information as possible about your sources. Normally, references are cited in a standard format, which varies only slightly between publishers of books or journals.

In the text, surname of the author with date of publication is given:

e.g. "... is described by Clarke (1969)..."
"... can be found in the "Contours" series (Andrews 1972)".

If there are more than two authors, is is convenient in the text to give the name of the first author followed by *et al.* in italics or underlined, followed by the date.

In the Bibliography, or References cited, use the format - Author, (surname and initials), date, title of article or book, or chapter in a book, followed by the name of the journal, or the editor of the book and its title, the publisher, and the number of pages.

e.g. Hosie, R.C. 1973. Native trees of Canada. 7th Ed., Can. Forestry Serv., Dept. Environ., Ottawa, 380 pp.
Muller, P. 1980. Effects of artificial acidification on the growth of periphyton. Can. J. Fish. Aquat. Sci., 37:355-363.

Always check that every reference in the text appears in the list of references. For some purposes, footnotes are acceptable, but these can be distracting and cumbersome and should generally be avoided.

It is good practice to make a rule that each reference is properly noted and a complete citation made *as soon as you locate it*. Most people find small cards can be used for a simple system, indexed under author, and if necessary cross-referenced for other topics. Much time can be wasted chasing references at the time of writing up the report, if the information on the sources at the time of collection was incomplete.

10.7 CONCLUSION/SUMMARY/ABSTRACT

The major points should be drawn together in one or two paragraphs, which should not include any detail but should reflect the aims, the major findings and any significant conclusions. Numerical data are not usually included, but a small number of well established values may be included - e.g. "The measurements showed 50% average increase in surface runoff in the devegetated area".

The abstract normally appears at the front of the report, and will be the first and possibly the only part which is used by some of your readers. Bear this in mind when you prepare it. In addition, since your report may appear in an abbreviated form for the purposes of indexing, the abstract should be as meaty and concise as possible. If you do not provide a good summary, the task may fall to another person who was not involved in the work, and may not give the emphasis you would wish.

10.8 THE APPENDICES

Reference has already been made to the inclusion of raw data tables as appendices. In addition, appendices might include data from other workers, peripheral information on geographical locations, lists of suppliers for equipment, formulae for reagents, etc.

10.9 THE FINAL TOUCHES, REVIEWS AND CORRECTIONS

When the report is drafted, you should ideally allow some time to elapse before making the final corrections. If you do this immediately the report is finished, you may overlook certain shortcomings in terms of what you actually wrote compared with what you meant to say. Try reading the report aloud; clumsy or unclear sentences may become apparent when you hear them. Invite the criticism of a colleague or acquaintance who is not too familiar with your subject matter. If some aspects are unclear to intelligent but uninformed readers, then consider how the points could be clarified.

When your report is completed, what happens to the raw data (if they were not appended) and the field notes? Local groups and regional governments which sponsor field studies often have no facility to maintain a file of data. The Ontario Ministry of Natural Resources (or the corresponding provincial government agency) does have an interest in such material - especially for the selection and evaluation of nature reserves - and has facilities for storage. In Ontario this is the Branch Heritage Resources Centre and the contact person is the current Director of Parks and Recreational Areas.

REFERENCES

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Heath, O.O.S. 1970. Investigation by experiment. Edward Arnold, London, 74 pp.

Hopkins, C. 1973. Ecology in searching for structure. Holt Rinehart, Winston, 92 pp.

Huff, D. 1954. (1st Ed.) How to lie with statistics. Pelican Books,

Meadows, D.H. 1972. The limits to growth. Universe Books, New York, 205 pp.

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Weather, published by the Royal Meteorological Society, Bracknell, Berks. U.K.

From these guidelines, you should be able to devise systems and methods for your own specific task. Writing a report need not be a tedious ordeal. If it is based on good planning, and broken down into a series of logical steps, it can be a satisfying and exciting task. Above all, the end result should do justice to the work that went into the study at all stages.

APPENDIX 1

UNITS OF MEASUREMENT

Internationally accepted prefixes and their symbols.

NAME	SYMBOL	MEANING	EXAMPLE (LENGTH)
deci-	d	1/10 or $x10^{-1}$	decimetre (dm)
centi-	c	1/100 or $x10^{-2}$	centimetre (cm)
milli-	m	1/1000 or $x10^{-3}$	millimetre (mm)
micro-	μ	one millionth or $x10^{-6}$	micrometre (μm)
nano-	n	one billionth or $x10^{-9}$	nanometre (nm)

Note:

New nomenclature	Old nomenclature
one micrometre (1 μm)	= one micron (1 μ)
one nanometre (1 nm)	= one millimicron (1 mμ)

APPENDIX 2

SOME USEFUL CONVERSION FACTORS

1 metre (m) = 100 centimetres (cm) = 10^6 microns (μ) = 10^{10} angstroms (Å)
= 39.37 inches (in) = 3.281 feet (ft) = 1.094 yards (yd)

1 kilometre (km) = 1000 m = 0.6214 statute mile (mi) = 0.5400 nautical mile

1 m^2 = 10^4 cm^2 = 10.76 ft^2 = 1.196 yd^2

1 km^2 = 10^6 m^2 = 100 hectares (ha) = 247.1 acres = 0.3861 mi^2

1 litre (L) = 1000 cm^3 = 33.81 fluid ounces = 1.057 U.S. quarts

1 m^3 = 10^3 L = 35.31 ft^3 = 264.2 U.S. gallons = 6.290 barrels

1 km^3 = 10^9 m = 0.2399 mi^3 = 810,600 acre-feet

1 gram (g) = 15.43 grains = 0.03527 ounces avoirdupois = 0.03215 troy ounces

1 kilogram (kg) = 1000 g = 2.205 pounds (lb) = 35.27 ounces avoirdupois

1 metric ton (MT) = 1000 kg = 1.102 short tons = 0.9842 long tons

1 day = 1440 min - 86,400 sec

1 yr = 8760 hr = 3.154 x 10^7 sec

1 knot = 0.5144 m/sec = 1.852 km/hr = 1.151 mi/hr

1 ft^3/sec (cfs) = 448.9 gal/min = 8.931 x 10^5 m^3/yr = 724.0 acre-ft/yr

degrees Celsius (°C) = degrees Kelvin (°K) - 273.16
= (5/9) x (degrees Fahrenheit (°F) - 32)

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